US009222120B2

(12) **United States Patent**
Crawford et al.

(10) **Patent No.: US 9,222,120 B2**
(45) **Date of Patent: *Dec. 29, 2015**

(54) **QUANTIFICATION OF NON-REDUCING END GLYCAN RESIDUAL COMPOUNDS FOR DETERMINING THE PRESENCE, IDENTITY, OR SEVERITY OF A DISEASE OR CONDITION**

(71) Applicant: **BIOMARIN PHARMACEUTICAL INC.**, Novato, CA (US)

(72) Inventors: **Brett E. Crawford**, Poway, CA (US); **Jilllian R. Brown**, Poway, CA (US); **Charles A. Glass**, San Diego, CA (US); **Jim R. Beitel**, San Diego, CA (US); **Robin M. Jackman**, San Diego, CA (US)

(73) Assignee: **BioMarin Pharmaceutical Inc.**, Novato, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **14/321,413**

(22) Filed: **Jul. 1, 2014**

(65) **Prior Publication Data**

US 2014/0308684 A1 Oct. 16, 2014

Related U.S. Application Data

(63) Continuation of application No. 13/550,106, filed on Jul. 16, 2012, now Pat. No. 8,771,974, which is a continuation of application No. 12/649,110, filed on Dec. 29, 2009, now Pat. No. 8,232,073.

(60) Provisional application No. 61/238,079, filed on Aug. 28, 2009, provisional application No. 61/164,365, filed on Mar. 27, 2009, provisional application No. 61/142,291, filed on Jan. 2, 2009.

(51) **Int. Cl.**

C12Q 1/40	(2006.01)
C12Q 1/527	(2006.01)
G01N 33/68	(2006.01)
C12Q 1/34	(2006.01)

(52) **U.S. Cl.**

CPC ***C12Q 1/527*** (2013.01); ***C12Q 1/34*** (2013.01); ***C12Q 1/40*** (2013.01); ***G01N 33/6893*** (2013.01); *G01N 2333/924* (2013.01); *G01N 2400/00* (2013.01); *G01N 2800/042* (2013.01); *G01N 2800/52* (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,185,245	A	2/1993	Heimer	
6,117,647	A	9/2000	Romisch et al.	
6,143,730	A	11/2000	Parish et al.	
6,653,285	B1	11/2003	Takashima et al.	
6,852,696	B2	2/2005	Takashima et al.	
6,923,965	B2	8/2005	Takashima et al.	
6,936,424	B1	8/2005	Watkins et al.	
7,651,847	B2	1/2010	Lebrilla et al.	
8,232,073	B2 *	7/2012	Crawford et al.	435/15
8,771,974	B2 *	7/2014	Crawford et al.	435/15
2002/0102737	A1	8/2002	Millington et al.	
2003/0024012	A1	1/2003	Abdennebi-Najar et al.	
2003/0054991	A1	3/2003	Takashima et al.	
2003/0228259	A1	12/2003	Hellerstein	
2004/0138105	A1	7/2004	Takashima et al.	
2005/0159343	A1	7/2005	Takashima et al.	
2005/0238536	A1	10/2005	Striepeke et al.	
2006/0269974	A1	11/2006	Dwek et al.	
2006/0286034	A1	12/2006	Meikle et al.	
2007/0161074	A1	7/2007	Tomatsu et al.	
2008/0071148	A1	3/2008	Bosques et al.	
2008/0153752	A1	6/2008	Takashima et al.	
2010/0184013	A1	7/2010	Crawford et al.	
2012/0009616	A1	1/2012	Crawford et al.	
2012/0289415	A1	11/2012	Bosques et al.	
2013/0149729	A1	6/2013	Crawford et al.	

FOREIGN PATENT DOCUMENTS

GB	2468386	A	9/2010
WO	01/31045	A1	5/2001
WO	01/36977	A2	5/2001
WO	01/94941	A2	12/2001
WO	01/94941	A3	8/2003
WO	03/092601	A2	11/2003
WO	03/106997	A1	12/2003
WO	2004/019040	A1	3/2004
WO	03/092601	A3	9/2004
WO	2007/010089	A2	1/2007
WO	2007/010089	A3	5/2007
WO	2007/138263	A1	12/2007
WO	2010/078511	A2	7/2010

(Continued)

OTHER PUBLICATIONS

An et al., "Glucose tetrasaccharide as a biomarker for monitoring the therapeutic response to enzyme replacement therapy for Pompe disease," Mol. Genet. Metab. 85(4):247-254 (2005).

An et al., "Profiling of glycans in serum for the discovery of potential biomarkers for ovarian cancer," J. Proteome Res. 5(7):1626-1635 (2006).

Byers et al., "Glycosaminoglycan accumulation and excretion in the mucopolysaccharidoses: Characterization and basis of a diagnostic test for MPS," Molecular Genetics and Metabolism, 65(4):282-290 (1998).

(Continued)

Primary Examiner — Ralph Gitomer

(74) *Attorney, Agent, or Firm* — Jones Day

(57) **ABSTRACT**

Provided herein are methods of diagnosing or monitoring the treatment of abnormal glycan accumulation or a disorder associated with abnormal glycan accumulation.

21 Claims, 4 Drawing Sheets

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

WO	2010/078514 A2	7/2010
WO	2010/078511 A3	10/2010

OTHER PUBLICATIONS

Calabro et al., "Adaptation of FACE methodology for microanalysis of total hyaluronan and chondroitin sulfate composition from cartilage," Glycobiology 10(3):283-293 (2000).

Calabro et al., "Microanalysis of enzyme digests of hyaluronan and chondroitin/dermatan sulfate by fluorophore-assisted carbohydrate electrophoresis (FACE)," Glycobiology 10(3):273-281 (2000).

Daud et al., "Synthetic heparin pentasaccharide depolymerization by heparinase 1: Molecular and biological implications," Clin. Appl. Thromb. Hemost. 7(1):58-64 (2001).

Deakin and Lyon, "A simplified and sensitive fluorescent method for disaccharide analysis of both heparin sulfate and chondroitin-dermatan sulfates from biological samples," Glycobiology 18(6):483-491 (2008).

Deegan et al., "Clinical evaluation of chemokine and enzymatic biomarkers of Gaucher disease," Blood Cells Mol. Dis. 35(2):259-267 (2005).

Delaney et al., "A high-performance liquid chromatography approach for isolation and sequencing of chondroitin sulfate oligosaccharides," Anal. Biochem. 108(1):25-34 (1980).

Ferro et al., "Evidence of conformational equilibrium of the sulfated L-iduronate residue in heparin and in synthetic heparin mono- and oligosaccharides: NMR and force-field studies," J. Am. Chem. Soc. 108:6778-6784 (1986).

Freeman and Hopwood, "Human α-L-iduronidase. Catalytic properties and an integrated role in the lysosomal degradation of heparan sulphate," Biochem. J. 282(Pt 3):899-908 (1992).

Fuller et al., "Glycosaminoglycan degradation fragments in mucopolysaccharidosis I," Glycobiology 14(5):443-450 (2004).

Hansen et al., "HPLC glycosaminoglycan analysis in patients with Graves' disease," Clin. Sci. (Lond) 92(5):511-517 (1997).

Hitchcock et al., "Comparative glycomics of connective tissue glycosaminoglycans," Proteomics 8(7):1384-1397 (2008).

Honda et al., "High-performance capillary electrophoresis of unsaturated oligosaccharides derived from glycosaminoglycans by digestion with chondroitinase ABC as 1-phenyl-3 methyl-5-pyrazolone derivatives," J. Chromatogr. 608(1-2):289-295 (1992).

Hopwood and Elliott, "Urinary excretion of sulphated N-acetylhexosamines in patients with various mucopolysaccharidoses," Biochem. J. 229(3):579-586 (1985).

Imanari et al., "High performance liquid chromatographic analysis of glycosaminoglycan-derived oligosaccharides," J. Chromatogr. A. 720(1-2):275-293 (1996).

International Search Report and Written Opinion for PCT/US2009/069946 dated Sep. 9, 2012.

International Search Report for PCT/US2009/069941 mailed Aug. 27, 2010.

International Search Report for PCT/US2009/069944 mailed Aug. 31, 2010.

International Search Report for PCT/US2013/061914 mailed Dec. 17, 2013.

Jacquinet et al., "Synthesis of heparin fragments. A chemical synthesis of the trisaccharideO-(2-deoxy-2-sulfamido-3,6-di-O-sulfo-α-d-glucopyranosyl)-(1→4)-O-(2-O-sulfo-α-l-idopyranosyluronic acid)-(1→4)-2-deoxy-2-sulfamido-6-O-sulfo-d-glucopyranose heptasodium salt," Carbohydr. Res. 130:221-241 (1984).

Kimura et al., "Chemical structure of urinary dermatan sulfate excreted by a patient with the Hunter syndrome," Tohoku J. Exp. Med. 131(3):241-247 (1980).

Kimura et al., "Fractionation and characterization of urinary heparan sulfate excreted by patients with Sanfilippo syndrome," Tohoku J. Exp. Med. 144(3):227-236 (1984).

Kirmiz et al., "A serum glycomics approach to breast cancer biomarkers," Mol. Cell. Proteomics 6(1).43-55 (2007).

Kodama et al., "High-performance liquid chromatography of pyridylamino derivatives of unsaturated disaccharides produced from chondroitin sulfate isomers by chondroitinases," J. Biochem. 96(4):1283-1287 (1984).

Kodama et al., "Liquid-chromatographic determination of urinary glycosaminoglycans for differential diagnosis of genetic mucopolysaccharidoses," Clin. Chem. 31(1 Pt 1):30-34 (1986).

Lawrence et al., "Evolutionary differences in glycosaminoglycan fine structure detected by quantitative glycan reductive isotope labeling," J. Biol. Chem. 283(48):33674-33684 (2008).

MacCari et al., "Anomolous structure of urinary glycosaminoglycans in patients with pseudoxanthoma elasticum," Clin. Chem. 49(3):380-388 (2003).

Mahuran, "Biochemical consequences of mutations causing the GM2 gangliosidoses," Biochim. Biophys. Acta 1455 (2-3):105-138 (1999).

Mao et al., "Capillary electrophoresis for the analysis of glycosaminoglycans and glycosaminoglycan-derived oligosaccharides," Biomed. Chromatogr. 16(2):77-94 (2002).

Mason et al., "Characterization of sulfated oligosaccharides in mucopolysaccharidosis type IIIA by electrospray ionization mass spectrometry," Anal. Chem. 78(13):4534-4542 (2006).

Matzner et al., "Enzyme replacement improves nervous system pathology and function in a mouse model for metachromatic leukodystrophy," Hum. Mol. Genet. 14(9):1139-1152 (2005) (Epub Mar. 16, 2005).

Minamisawa et al., "Microscale preparation of even- and odd-numbered N-acetylheparosan oligosaccharides," Carbohydr. Res. 341(2):230-237 (2006).

Minamisawa et al., "Systematic identification of N-acetylheparosan oligosaccharides by tandem mass spectrometric fragmentation," Rapid Commun. Mass Spectrom. 20:267-274 (2006).

Nader et al., "Chemistry of heparitin sulfate and heparin from normal tissues and from patients with Hunter syndrome," Biochim Biophys Acta. 582(1):33-43 (1979).

Nomenclature Committee Consortium for Functional Glycomics "Symbol and Text Nomenclature for Representation of Glycan Structure" (May 2012) accessed on internet on Sep. 12, 2012 at http://www.functionalglycomics.org/static/consortium/Nomenclature.shtml.

Plaas et al., "Glycosaminoglycan sulfation in human osteoarthritis: Disease-related alterations at the non-reducing termini of chondroitin and dermatan sulfate," J. Biol. Chem. 273(20):12642-12649 (1998).

Pol-Fachin and Verli, "Depiction of the forces participating in the 2-O-sulfo-α-L-iduronic acid conformational preference in heparin sequences in aqueous solutions," Carbohydr. Res. 343:1435-1445 (2008).

Rhomberg et al., "Mass spectrometric evidence for the enzymatic mechanism of the depolymerization of heparin-like glycosaminoglycans by heparinase II," Proc. Natl. Acad. U.S.A. 95(21):12232-12237 (1998).

Thanawiroon et al., "Liquid chromatography/mass spectrometry sequencing approach for highly sulfated heparin-derived oligosaccharides," J. Biol. Chem. 279(4):2608-2615 (2004).

Thompson et al., "Oligosaccharide substrates for heparin sulfamielase," Anal. Chem. 152:412-422 (1986).

Toma et al., "Differences in the non-reducing ends of heparan sulfates excreted by patients with mucopolysaccharidoses revealed by bacterial heparitinases: A new tool for structural studies and differential diagnosis of Sanfilippo's and Hunter's syndromes," Lab. Invest. 75(6): 771-781 (1996).

(56) **References Cited**

OTHER PUBLICATIONS

Volpi et al., "Mass spectrometry for the characterization of unsulfated chondroitin oligosaccharides from 2-mers to 16-mers. Comparison with hyaluronic acid oligomers," Rapid Commun. Mass Spectrom. 22(22):3526-3530 (2008).

Yamada et al., "Structural studies on the tri- and tetrasaccharides isolated from porcine intestinal heparin and characterization of heparinase/heparitinases using them as substrates," Glycobiology 4(1):69-78 (1994).

Yan et al., "Prediction and simulation on interaction between HIV-1 envelope protein gp120 and heparin," Chem. J. Chinese U. 25(3):522-525 (2004). (in Chinese with English abstract).

Yosizawa et al., "A simple method for the quantitation of glycuronic acid-containing glycosaminoglycans with mucopolysaccharidases," Anal. Biochem. 128(1):250-256 (1983).

* cited by examiner

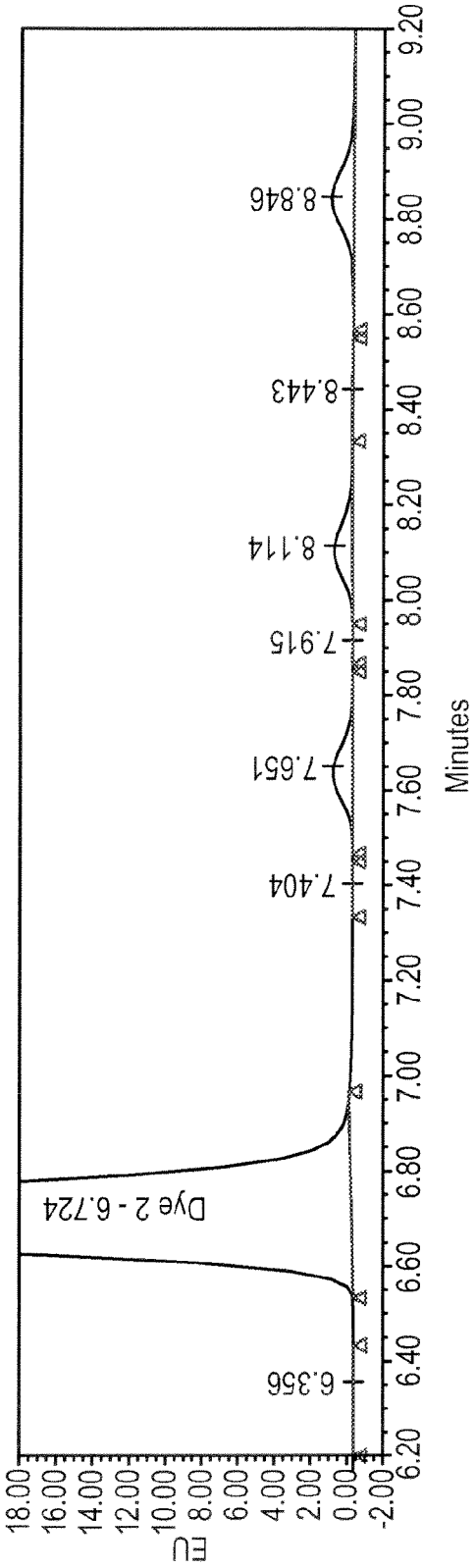
EU
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
6.20
6.40
6.60
6.80
7.00
7.20
7.40
7.60
7.80
8.00
8.20
8.40
8.60
8.80
9.00
9.20
Minutes
6.356
Dye 2 - 6.724
7.404
7.651
7.915
8.114
8.443
8.846

FIG. 1

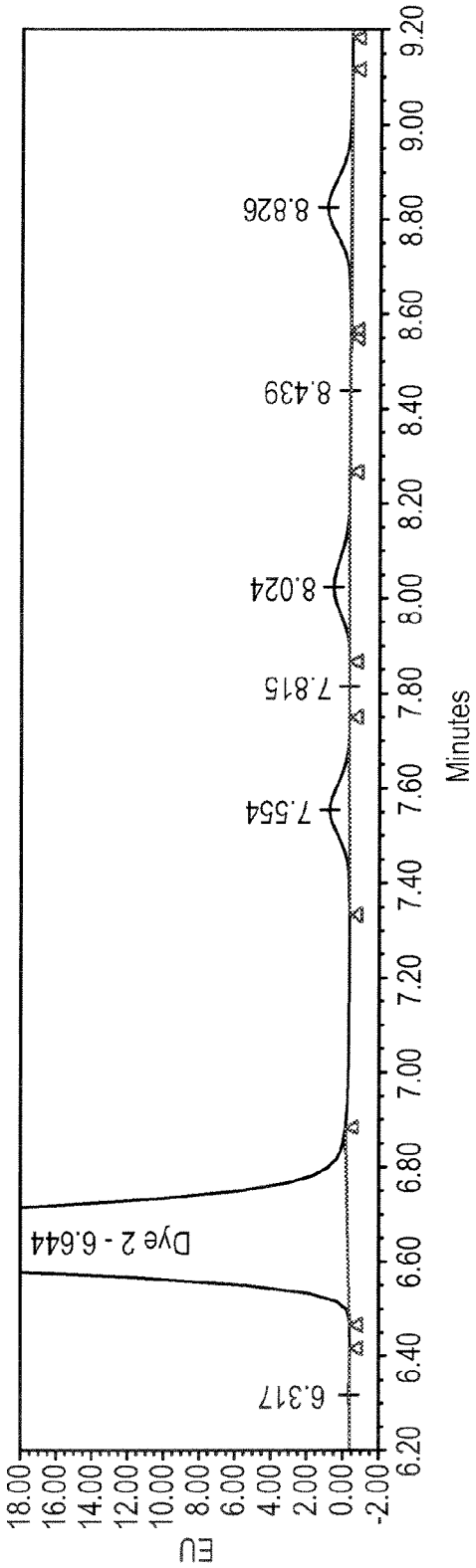
FU
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
6.20
6.40
6.60
6.80
7.00
7.20
7.40
7.60
7.80
8.00
8.20
8.40
8.60
8.80
9.00
9.20
Minutes
6.317
Dye 2 - 6.644
7.554
7.815
8.024
8.439
8.826

FIG. 2

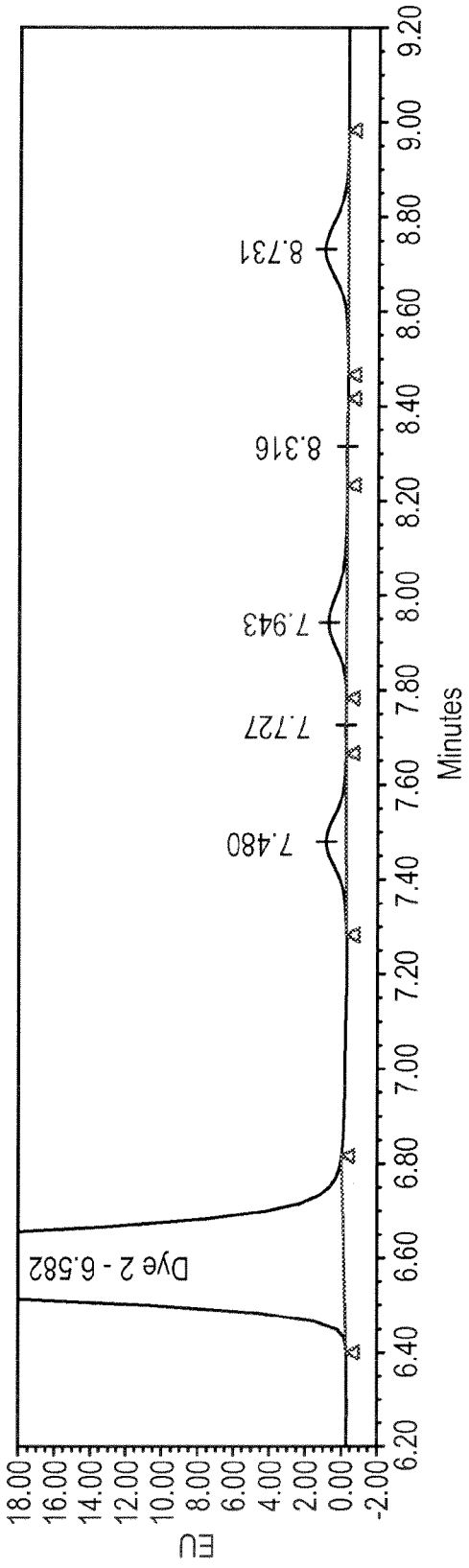
EU
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
6.20
6.40
6.60
6.80
7.00
7.20
7.40
7.60
7.80
8.00
8.20
8.40
8.60
8.80
9.00
9.20
Minutes
Dye 2 - 6.582
7.480
7.727
7.943
8.316
8.731

FIG. 3

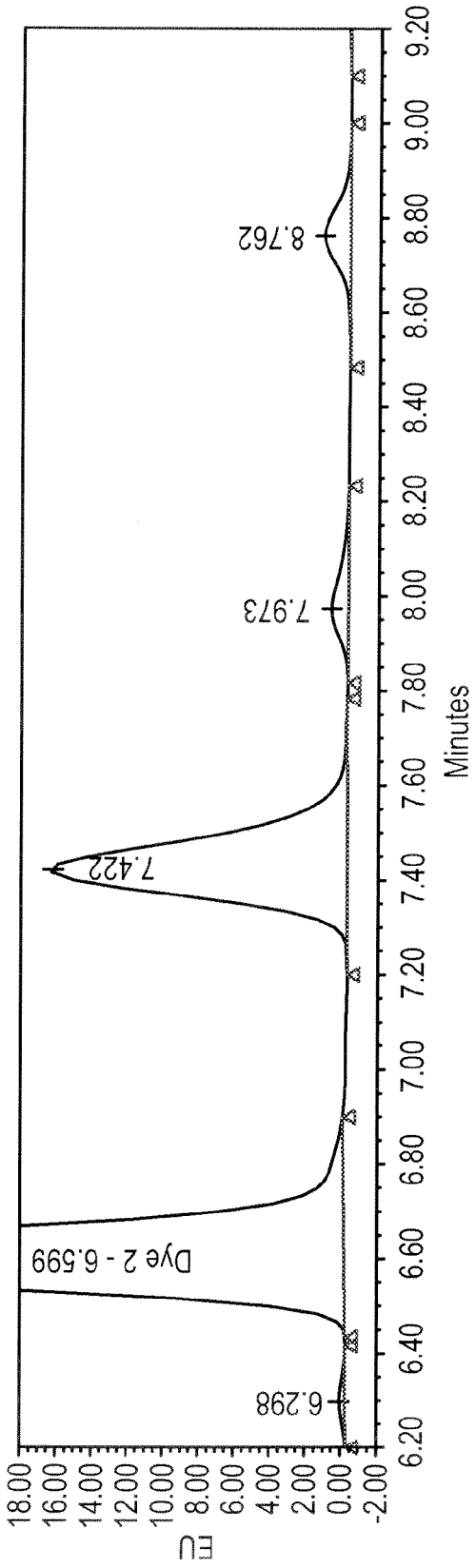
RFU
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
6.20
6.40
6.60
6.80
7.00
7.20
7.40
7.60
7.80
8.00
8.20
8.40
8.60
8.80
9.00
9.20
Minutes
6.298
Dye 2 - 6.599
7.422
7.973
8.762

FIG. 4

QUANTIFICATION OF NON-REDUCING END GLYCAN RESIDUAL COMPOUNDS FOR DETERMINING THE PRESENCE, IDENTITY, OR SEVERITY OF A DISEASE OR CONDITION

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 13/550,106, filed Jul. 16, 2012 (now U.S. Pat. No. 8,771,974), which is a continuation of U.S. patent application Ser. No. 12/649,110, filed Dec. 29, 2009 (now U.S. Pat. No. 8,232,073), which claims the benefit of U.S. Provisional Application No. 61/142,291, filed Jan. 2, 2009, U.S. Provisional Application No. 61/164,365, filed Mar. 27, 2009, and U.S. Provisional Application No. 61/238,079, filed Aug. 28, 2009, each of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

Many human diseases are caused by or correlated with changes in glycosylation. In order to use these changes as biomarkers of disease, analytical methods are used to quantify the changes. The published methods use antibodies, chromatography and/or mass spectrometry techniques to resolve and quantify the intact or partially intact glycans. These methods are challenging due to the complexity and number of possible glycan structures present in biological samples. In a single disease state there can be thousands of different novel glycan structures that are present; however, each on their own is a weak marker of disease.

SUMMARY OF THE INVENTION

Described herein are populations of glycans that are transformed into populations of biomarkers using glycan degradation enzymes. Further described herein are the use of analytical instruments to characterize the population of biomakers (i.e., non-reducing end glycan residual compounds, such as monosaccharides) in order to provide relevant information about the population of biomarkers, the population of biomarkers and the biological sample that provided the population of biomarkers.

Provided in certain embodiments herein are methods of detecting glycan accumulation and/or abnormal glycan biosynthesis and/or degradation in a biological sample, the method comprising:

a. transforming a glycan of a biological sample with a glycan degradation enzyme to liberate a glycan residual compound from the non-reducing end of the glycan;
b. measuring the amount of the glycan residual compound liberated by the functioning glycan degradation enzyme with an analytical device.

In some embodiments, a method described herein comprises a method of diagnosing an individual as having a disease or condition associated with abnormal glycan biosynthesis, degradation, or accumulation, the method comprising:

a. generating a biomarker comprising of one or more non-reducing end glycan residual compound, wherein the biomarker is generated by treating a population of glycans, in or isolated from a biological sample from the individual, with at least one digesting glycan enzymes, wherein prior to enzyme treatment, the biomarker is not present in abundance in samples from individuals with the disease or condition relative to individuals without the disease or condition, and

b. using an analytical instrument to detect the presence of and/or measure the amount of the biomarker produced and displaying or recording the presence of or a measure of a population of the biomarker;

In some embodiments, the presence of and/or measure the amount of the biomarker is utilized to determine the presence, identity, and/or severity of the disease or condition.

Provided in certain embodiments herein is a method of diagnosing an individual as having a disease or condition associated with abnormal glycan biosynthesis, degradation, or accumulation, the method comprising:

a. transforming a glycan of a biological sample with a glycan degradation enzyme to liberate a glycan residual compound from the non-reducing end of the glycan;
b. measuring the amount of the glycan residual compound liberated by the functioning glycan degradation enzyme with an analytical device; and
c. determining whether the amount of liberated glycan residue is abnormal.

In some embodiments, provided herein is a method of monitoring the treatment of a disorder associated with the abnormal degradation, biosynthesis and/or accumulation of glycans, the method comprising:

a. following administration of an agent for treating a disorder associated with the abnormal degradation, biosynthesis and/or accumulation of glycans to an individual in need thereof, using an analytical instrument to measure the amount of a population of a biomarker comprising a non-reducing end glycan residual compounds present in a transformed biological sample, the biomarker being generated by treating a population of glycans, in or isolated from a biological sample from the individual, with at least one digesting glycan enzyme(s), wherein prior to enzyme treatment, the biomarker is not present in abundance in samples from individuals with the disease or condition relative to individuals without the disease or condition, and
b. determining whether or not the amount of the amount of biomarker has decreased or increased at a slower rate compared to the amount or rate of increase prior to administration of the agent for treating a disorder associated with the abnormal degradation, biosynthesis and/or accumulation of glycans.

In some embodiments, the abnormal glycan accumulation or disorder associated therewith is caused by an abnormally functioning glycan degradation enzyme and wherein the abnormally functioning glycan degradation enzyme and glycan degradation enzyme are of the same type (e.g., the glycan degradation utilized in the transformation process is a functioning glycan degradation enzyme whereas the abnormally functioning enzyme is not, such as due to deletions, insertions, substitutions, or other modifications to the enzyme sequence). In certain embodiments, the abnormally functioning glycan degradation enzyme functions abnormally as a result of being present in an abnormally low amount, functioning improperly, or a combination thereof. In some embodiments, the abnormal glycan accumulation comprises the accumulation of abnormal amounts of glycans. In certain embodiments, the abnormal glycan accumulation comprises the accumulation of abnormal amounts of normal glycans. In some embodiments, the abnormal glycan accumulation comprises the accumulation of abnormal amounts of abnormal glycans.

In certain embodiments, the biomarker is not present in the original biological sample. In some embodiments, the biomarker is not present in the biological sample after isolating a

population of glycans therefrom (e.g., prior to transformation of the glycan according to a process described herein).

In certain embodiments, the normally functioning glycan degradation enzyme is a glycosidase, sulfatase, phosphorylase, deacetylase or a combination thereof. In some embodiments, the normally functioning glycan degradation enzyme is a glycosidase selected from an exo-glycosidase and an endo-glycosidase. In certain embodiments, the glycosidase is an exo-glycosidase selected from the group consisting of a galactosidase, and a glucuronidase. In some embodiments, the generated biomarker is a glycan residual compound. In some embodiments, the glycan residual compound is a monosaccharide. In certain embodiments, the glycan residual compound is sulfate, phosphate, acetate, or a combination thereof. In certain embodiments, the glycan residual compound has a molecular weight of less than 2000 g/mol, less than 1500 g/mol, less than 1000 g/mol, less than 500 g/mol, less than 400 g/mol, less than 300 g/mol, less than 260 g/mol, less than 200 g/mol, less than 100 g/mol, or the like (e.g., prior to tagging with any detectable label that may be included in a process described herein).

In some embodiments, any process described herein further comprises purifying a biological sample prior to transforming a glycan thereof. In some embodiments, the process of purifying a biological sample comprises removing monosaccharides therefrom, removing sulfates therefrom, removing phosphates therefrom, removing acetate therefrom, or a combination thereof.

In certain embodiments, transforming a glycan of a biological sample with a normally functioning glycan degradation enzyme comprises transforming a glycan of a biological sample with a plurality of normally functioning glycan degradation enzymes. In some embodiments, the glycan is treated with a plurality of normally functioning glycan degradation enzymes concurrently, sequentially, or a combination thereof.

In specific embodiments, a disorder associated with an abnormal glycan accumulation is any disorder described in Tables 1-4 (e.g., MPS I) and the normally functioning glycan degradation enzyme is any enzyme described in Tables 1-4 (e.g., L-iduronidase).

In some embodiments, determining whether the amount of liberated glycan residue is abnormal comprises labeling the glycan residue with a detectable label and measuring the amount of labeled glycan residue with an analytical instrument. In certain embodiments, the detectable label is a mass label, a radioisotope label, a fluorescent label, a chromophore label, or affinity label. In some embodiments, the amount of liberated glycan is measured using UV-V is spectroscopy, IR spectroscopy, mass spectrometry, or a combination thereof

Provided in some embodiments herein is a method of monitoring the treatment of a disorder associated with the abnormal degradation, biosynthesis and/or accumulation of glycans, the methods comprising:

a. following administration of an agent for treating a disorder associated with the abnormal degradation, biosynthesis and/or accumulation of glycans to an individual in need thereof, using an analytical instrument to measure the amount of a population of a non-reducing end glycan residual compounds present in a transformed biological sample that has been prepared by:

treating a population of glycans, in or isolated from a biological sample taken from the individual, with at least one normally functioning glycan degradation enzyme to liberate non-reducing end glycan residual compound;

b. determining whether or not the amount of the amount of liberated non-reducing end glycan residue has decreased or increased at a slower rate compared to the amount or rate of increase prior to administration of the agent for treating a disorder associated with the abnormal degradation, biosynthesis and/or accumulation of glycans.

In some embodiments, the disorder associated with the abnormal degradation, biosynthesis and/or accumulation of glycans is a lysosomal storage disease, a cancerous disease, or an infectious disease. In certain embodiments, the normally functioning glycan degradation enzyme is a glycosidase, sulfatase, phosphorylase, deacetylase, or a combination thereof. In some embodiments, the normally functioning glycan degradation enzyme is a glycosidase selected from an exo-glycosidase and an endo-glycosidase. In certain embodiments, the glycan residual compound is a monosaccharide, sulfate, phosphate, acetate, or a combination thereof. In some embodiments, transforming a glycan of a biological sample with a normally functioning glycan degradation enzyme comprises transforming a glycan of a biological sample with a plurality of normally functioning glycan degradation enzymes. In certain embodiments, the glycan is treated with a plurality of normally functioning glycan degradation enzymes concurrently, sequentially, or a combination thereof. In some embodiments, prior to measuring the amount of a population of non-reducing end glycan residual compounds, the non-reducing end glycan residual compounds are labeled with a detectable label. In certain embodiments, the detectable label is a mass label, a radioisotope label, a fluorescent label, a chromophore label, or affinity label. In some embodiments, the amount of liberated glycan is measured using UV-Vis spectroscopy, IR spectroscopy, mass spectrometry, or a combination thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

The novel features of the invention are set forth with particularity in the appended claims. A better understanding of the features and advantages of the present invention will be obtained by reference to the following detailed description that sets forth illustrative embodiments, in which the principles of the invention are utilized, and the accompanying drawings of which:

FIG. **1** illustrates compounds present in a normal biological sample not subject to an enzymatic glycan residual liberation process described herein.

FIG. **2** illustrates compounds present in a normal biological subject to an enzymatic glycan residual liberation process described herein.

FIG. **3** illustrates compounds present in a biological sample of an individual suffering from a disorder associated with abnormal glycan accumulation not subject to an enzymatic glycan residual liberation process described herein.

FIG. **4** illustrates compounds present in a biological sample of an individual suffering from a disorder associated with abnormal glycan accumulation subject to an enzymatic glycan residual liberation process described herein.

DETAILED DESCRIPTION OF THE INVENTION

While preferred embodiments of the present invention have been shown and described herein, it will be obvious to those skilled in the art that such embodiments are provided by way of example only. Numerous variations, changes, and substitutions will now occur to those skilled in the art without departing from the invention. It should be understood that various alternatives to the embodiments of the invention

described herein may be employed in practicing the invention. It is intended that the following claims define the scope of the invention and that methods and structures within the scope of these claims and their equivalents be covered thereby.

Provided herein is a method of detecting abnormal glycan accumulation, e.g., in human disease. In some instances, the process described herein includes a strategy to quantify the changes by measuring the abundance of all glycans with a disease related glycan residual compound on the non-reducing end of glycans from a biological sample (e.g., monosaccharides and/or their modifications such as sulfation, acetylation, phosphorylation, or the like).

Provided in certain embodiments herein are methods of detecting glycan accumulation in a biological sample, the method comprising:

a. transforming a glycan of a biological sample with a normally functioning glycan degradation enzyme to liberate a glycan residual compound from the non-reducing end of the glycan;
b. measuring the amount of the glycan residual compound liberated by the functioning glycan degradation enzyme with an analytical device.

In certain embodiments, the method is associated with diagnosing an individual with abnormal glycan accumulation, or a disorder associated therewith.

Therefore, in specific embodiments, provided herein is a method of diagnosing an individual as having an abnormal glycan accumulation or a disorder associated with an abnormal glycan accumulation, the method comprising:

a. transforming a glycan of a biological sample with a normally functioning glycan degradation enzyme to liberate a glycan residual compound from the non-reducing end of the glycan;
b. measuring the amount of the glycan residual compound liberated by the functioning glycan degradation enzyme with an analytical device; and
c. determining whether the amount of liberated glycan residue is abnormal.

In certain instances, methods of detecting abnormal glycan accumulation works based on the observation that altered glycans generated in a disease state are caused by an alteration in the activity of a biosynthetic enzyme (e.g., via increased expression, increased activity, increased substrate, or the like) that leads to the production of thousands of unique structures.

For example, in certain instances, the induction of an alpha 2,3 sialyltransferase leads to the novel expression of thousands of different glycans (potentially from multiple glycan classes) that present a non-reducing terminal alpha 2,3 linked sialic acid. By quantifying a limited set of these novel structures using current methods, only a fraction of the disease related structures are measured. Instead, as provided in certain embodiments herein, if a sample containing glycans (crude or purified for a specific glycan class) is treated with an alpha 2,3 sialidase to liberate the non-reducing end sialic acid, the free sialic acid (non-reducing end glycan residual) can be measured. This signal would represent a larger portion of the thousands of altered glycan structures that are made in the disease state due to the altered expression of the alpha 2,3 sialyltransferase. Furthermore, in certain embodiments, depending on the signal (i.e., measurement) of the sialic acid liberated, a determination is made as to whether or not the accumulation of sialic acid is abnormal and/or whether or not such levels of accumulated sialic acid is associated with a disorder.

Another example of the process includes a method involving a biological sample containing glycans (purified or not) that is treated with an exo-glycosidase (for example a β-galactosidase). In some of such embodiments, enzymatic treatment cleaves non-reducing end monosaccharides within the chosen enzymes specificity (e.g., β-linked galactose residues) and liberates them as free monosaccharide (e.g., galactose). In various embodiments, the free monosaccharide is isolated and quantified by any analytical method (HPLC, MS, GC, etc), and any disease that presents changes in the levels of non-reducing end β-linked galactose residues is detected or diagnosed.

Similar methods are also optionally utilized in methods of monitoring and/or determining the therapeutic of a treatment or treatment regimen, particularly in the treatment of a disorder associated with abnormal glycan accumulation. For example, provided in certain embodiments herein is a method of monitoring the treatment of disorders associated with the abnormal degradation, biosynthesis and/or accumulation of glycans, the methods comprising:

a. following administration of an agent for treating a disorder associated with the abnormal degradation, biosynthesis and/or accumulation of glycans to an individual in need thereof, using an analytical instrument to measure the amount of a population of a non-reducing end glycan residue present in a transformed biological sample that has been prepared by:
   treating a population of glycans, in or isolated from a biological sample taken from the individual, with at least one normally functioning glycan degradation enzyme to liberate non-reducing end glycan residue;
b. determining whether or not the amount of the amount of liberated non-reducing end glycan residue has decreased or increased at a slower rate compared to the amount or rate of increase prior to administration of the agent for treating a disorder associated with the abnormal degradation, biosynthesis and/or accumulation of glycans.

In some embodiments, any process described herein comprises:

a. comparing an amount of a population of one or more glycan residual compound present in a transformed biological sample to an amount of a population of one or more glycan residual compound present in a control biological sample that has been treated in a manner substantially similar to the transformed biological sample.

In certain embodiments, a control biological sample utilized in any process described herein was provided from an individual that does not suffer from a disorder being diagnosed. In other embodiments, a control biological sample is taken from an individual suffering from a disorder being diagnosed. In certain embodiments, the result obtained from the control biological sample is stored in a database. In such cases a test sample is optionally compared to a plurality of control data in a database. Moreover in certain embodiments, any diagnostic process described herein is optionally utilized alone or in combination with other diagnostic techniques. Other diagnostic techniques include, by way of non-limiting example, symptom analysis, biopsies, detection of accumulation of other compounds in biological samples, or the like. In some embodiments, control biological samples are optionally taken from the same individual at substantially the same time, simply from a different location (e.g., one inflamed/arthritic synovial joint fluid vs the contralateral non-arthritic synovial joint). In other embodiments, control biological samples are optionally taken from the same individual at

different points in time (e.g., before therapy and after therapy if the method being utilized is a method of monitoring a treatment therapy).

Glycan Accumulation:

In various instances, glycan accumulation occurs in a biological sample as a result natural glycan biosynthetic and/or degradation processes. In some instances, abnormal glycan accumulation occurs in a biological sample as a result of a disorder or disease within an individual from which the biological sample is obtained.

In certain embodiments, abnormal glycan accumulation that is observable by methods described herein is associated with the accumulation of glycans in a manner that does not normally occur in individuals who are not in a disease state.

In some embodiments, such accumulation includes the accumulation of abnormal glycans. In certain instances, these abnormal glycans include glycans that are not normally produced in an individual, or a particular biological sample thereof, in the absence of a particular disease state. Therefore, in some embodiments, abnormal glycan accumulation includes the accumulation of glycans, the glycans being abnormal themselves, especially in any significant quantity. In other words, such glycans are abnormal glycans in individuals or particular biological samples thereof when such individuals are in a non-diseased, normal, or wild type state.

In some embodiments, such accumulation includes the abnormal accumulation of glycans. In some instances, these glycans are glycans that normally occur in individuals in a non-diseased state, but at lower or higher levels or are abnormal only due to the location wherein they are produced. Therefore, in some embodiments, abnormal glycan accumulation includes the accumulation of abnormal amounts of glycans or the location thereof, the glycans being normally occurring or abnormal glycans. In other words, the amount of glycan accumulation is abnormal in individuals, or particular biological samples thereof, when such individuals are in a non-diseased, normal, or wild type state.

Biological Sample:

Biological samples suitable for analysis according to the methods and processes described herein include, by way of non-limiting example, blood, serum, urine, hair, saliva, skin, tissue, plasma, cerebrospinal fluid (CSF), amniotic fluid, nipple aspirate, sputum, tears, lung aspirate, semen, feces, synovial fluid, nails, or the like. In specific embodiments, the biological samples suitable for analysis according to the methods and processes described herein include, by way of non-limiting example, urine, serum, plasma, or CSF. In certain embodiments, processes for detecting glycan in a sample comprise providing, from the individual, a test biological sample that comprises glycan. In some embodiments, providing a test biological sample from an individual includes obtaining the sample from the individual or obtaining the sample from another source (e.g., from a technician or institution that obtained the sample from the individual). In some embodiments, the biological sample is obtained from any suitable source, e.g., any tissue or cell (e.g., urine, serum, plasma, or CSF) of an individual. In certain embodiments, the tissue and/or cell from which the glycans are recovered is obtained from liver tissue or cells, brain tissue or cells, kidney tissue or cells, or the like.

In certain embodiments, a biological sample according to any process described herein is taken from any individual. In some embodiments, the individual is an individual suspected of suffering from a disorder associated with abnormal glycan accumulation, biosynthesis, and/or degradation. In certain embodiments, the individual is a newborn or fetus.

In some embodiments, provided herein is a composition comprising isolated glycans, wherein the glycans were isolated from a biological sample, and one or more glycan degradation enzyme. In certain embodiments, the composition further comprises one or more biomarker generated according to any method described herein (e.g., wherein the biomarker is a non-reducing end glycan residual compound). In certain embodiments, provided herein is a biomarker described herein (e.g., a labeled or non-labeled non-reducing end glycan residual compound) and an analytical instrument or chromatographic resin.

Degradation Enzymes:

In certain embodiments, any suitable enzyme is optionally utilized in order to remove a glycan residual compound from the non-reducing end of a glycan. In certain disorders, e.g., as described herein, various types of abnormal glycan accumulation occurs. In certain instances, this type of glycan accumulation is detected and/or measured utilizing any suitable enzyme, e.g., as described herein. For example, Tables 1-4 illustrate various enzymes that are utilized in various embodiments of the processes described herein. Any enzyme with the desired specificity is optionally utilized in any process herein (i.e., to liberate the non-reducing end structures). Enzymes suitable for use in the processes described herein include, by way of non-limiting example, eukaryotic, prokaryotic, native, or recombinant enzymes.

In certain embodiments, a disorder associated with abnormal glycan accumulation includes a disorder associated therewith is caused by an abnormally functioning glycan degradation enzyme. In various embodiments, the abnormally functioning glycan degradation enzyme functions abnormally as a result of being present in an abnormally low amount, functioning improperly, or a combination thereof. For example, an abnormally functioning glycan degradation enzyme functions abnormally as a result of being present in an amount of less than 50%, less than 40%, less than 30%, less than 20%, less than 10%, or less than 5% than is present in an individual with normal amounts of the glycan degradation enzyme (e.g., an individual in a non-diseased, normal, or wild type state). In further or alternative embodiments, abnormally functioning glycan degradation enzymes are present in a normal amount, but do not function properly in degrading glycans. For example, such enzymes may be have amino acid substitutions in the sequences thereof that reduce or eliminate the glycan degradative properties of the enzyme.

In some embodiments, wherein abnormal glycan accumulation results, at least partially from, an abnormally functioning glycan degradation enzyme, a normally functioning glycan degradation is optionally utilized, particularly wherein the abnormally functioning glycan degradation enzyme and the normally functioning glycan degradation enzyme are of the same type.

Normally functioning glycan degradation enzymes that are used in various embodiments described herein include, by way of non-limiting example, glycosidases, sulfatases, phosphorylases, deacetylases, sialidases, or combinations thereof. In more specific embodiments, a normally functioning glycan degradation enzyme is a glycosidase, e.g., an exo-glycosidase or an endo-glycosidase. In more specific embodiments, the glycosidase is an exo-glycosidase, e.g., galactosidase, and a glucuronidase. In some embodiments, such enzymes serve to remove various glycan residual compounds, such as, monosaccharides, sulfate, phosphate, acetate, sialic acid, or combinations thereof, which are detected and/or measured in methods described herein.

In certain embodiments, one or normally functioning glycan degradation enzyme is optionally utilized to liberate a

targeted glycan residual compound. Multiple enzyme treatments of glycans within a biological sample are useful in various embodiments, e.g., wherein a particular enzyme is unable to liberate a targeted residual glycan compound without first modifying the non-reducing end of the glycan. For example, a first enzyme is optionally utilized to remove a sulfate so that a second enzyme can be utilized to remove a monosaccharide. In various embodiments, the glycans are treated with a plurality of normally functioning glycan degradation enzymes concurrently, sequentially, or a combination thereof

Various enzymes that are used in various embodiments of the methods described herein include, by way of non-limiting example, a glycosidase. Non-limiting examples of glycosidase that are optionally utilized in the methods described herein include, by way of non-limiting example, enzymes categorized as 3.2.1.X by BRENDA (the comprehensive Enzyme Information System) including 3.2.1.1 alpha-amylase, 3.2.1.B1 extracellular agarase, 3.2.1.2 beta-amylase, 3.2.1.3 glucan 1,4-alpha-glucosidase, 3.2.1.4 cellulase, 3.2.1.5 licheninase, 3.2.1.6 endo-1,3(4)-beta-glucanase, 3.2.1.7 inulinase, 3.2.1.8 endo-1,4-beta-xylanase, 3.2.1.9 amylopectin-1,6-glucosidase, 3.2.1.10 oligo-1,6-glucosidase, 3.2.1.11 dextranase, 3.2.1.12 cycloheptaglucanase, 3.2.1.13 cyclohexaglucanase, 3.2.1.14 chitinase, 3.2.1.15 polygalacturonase, 3.2.1.16 alginase, 3.2.1.17 lysozyme, 3.2.1.18 exo-alpha-sialidase, 3.2.1.19 heparinase, 3.2.1.20 alpha-glucosidase, 3.2.1.21 beta-glucosidase, 3.2.1.22 alpha-galactosidase, 3.2.1.23 beta-galactosidase, 3.2.1.24 alpha-mannosidase, 3.2.1.25 beta-mannosidase, 3.2.1.26 beta-fructofuranosidase, 3.2.1.27 alpha-1,3-glucosidase, 3.2.1.28 alpha,alpha-trehalase, 3.2.1.29 chitobiase, 3.2.1.30 beta-D-acetylglucosaminidase, 3.2.1.31 beta-glucuronidase, 3.2.1.32 xylan endo-1,3-beta-xylosidase, 3.2.1.33 amylo-alpha-1,6-glucosidase, 3.2.1.34 chondroitinase, 3.2.1.35 hyaluronoglucosaminidase, 3.2.1.36 hyaluronoglucuronidase, 3.2.1.37 xylan 1,4-beta-xylosidase, 3.2.1.38 beta-D-fucosidase, 3.2.1.39 glucan endo-1,3-beta-D-glucosidase, 3.2.1.40 alpha-L-rhamnosidase, 3.2.1.41 pullulanase, 3.2.1.42 GDP-glucosidase, 3.2.1.43 beta-L-rhamnosidase, 3.2.1.44 fucoidanase, 3.2.1.45 glucosylceramidase, 3.2.1.46 galactosylceramidase, 3.2.1.47 galactosylgalactosylglucosylceramidase, 3.2.1.48 sucrose alpha-glucosidase, 3.2.1.49 alpha-N-acetylgalactosaminidase, 3.2.1.50 alpha-N-acetylglucosaminidase, 3.2.1.51 alpha-L-fucosidase, 3.2.1.52 beta-N-acetylhexosaminidase, 3.2.1.53 beta-N-acetylgalactosaminidase, 3.2.1.54 cyclomaltodextrinase, 3.2.1.55 alpha-N-arabinofuranosidase, 3.2.1.56 glucuronosyl-disulfoglucosamine glucuronidase, 3.2.1.57 isopullulanase, 3.2.1.58 glucan 1,3-beta-glucosidase, 3.2.1.59 glucan endo-1,3-alpha-glucosidase, 3.2.1.60 glucan 1,4-alpha-maltotetraohydrolase, 3.2.1.61 mycodextranase, 3.2.1.62 glycosylceramidase, 3.2.1.63 1,2-alpha-L-fucosidase, 3.2.1.64 2,6-beta-fructan 6-levanbiohydrolase, 3.2.1.65 levanase, 3.2.1.66 quercitrinase, 3.2.1.67 galacturan 1,4-alpha-galacturonidase, 3.2.1.68 isoamylase, 3.2.1.69 amylopectin 6-glucanohydrolase, 3.2.1.70 glucan 1,6-alpha-glucosidase, 3.2.1.71 glucan endo-1,2-beta-glucosidase, 3.2.1.72 xylan 1,3-beta-xylosidase, 3.2.1.73 licheninase, 3.2.1.74 glucan 1,4-beta-glucosidase, 3.2.1.75 glucan endo-1,6-beta-glucosidase, 3.2.1.76 L-iduronidase, 3.2.1.77 mannan 1,2-(1,3)-alpha-mannosidase, 3.2.1.78 mannan endo-1,4-beta-mannosidase, 3.2.1.79 alpha-L-arabinofuranoside hydrolase, 3.2.1.80 fructan beta-fructosidase, 3.2.1.81 beta-agarase, 3.2.1.82 exo-poly-alpha-galacturonosidase, 3.2.1.83 kappa-carrageenase, 3.2.1.84 glucan 1,3-alpha-glucosidase, 3.2.1.85 6-phospho-beta-galactosidase, 3.2.1.86 6-phospho-beta-glucosidase, 3.2.1.87 capsular-polysaccharide endo-1,3-alpha-galactosidase, 3.2.1.88 beta-L-arabinosidase, 3.2.1.89 arabinogalactan endo-1,4-beta-galactosidase, 3.2.1.90 arabinogalactan endo-1,3-beta-galactosidase, 3.2.1.91 cellulose 1,4-beta-cellobiosidase, 3.2.1.92 peptidoglycan beta-N-acetylmuramidase, 3.2.1.93 alpha,alpha-phosphotrehalase, 3.2.1.94 glucan 1,6-alpha-isomaltosidase, 3.2.1.95 dextran 1,6-alpha-isomaltotriosidase, 3.2.1.96 mannosyl-glycoprotein endo-beta-N-acetylglucosaminidase, 3.2.1.97 glycopeptide alpha-N-acetylgalactosaminidase, 3.2.1.98 glucan 1,4-alpha-maltohexaosidase, 3.2.1.99 arabinan endo-1,5-alpha-L-arabinosidase, 3.2.1.100 mannan 1,4-mannobiosidase, 3.2.1.101 mannan endo-1,6-alpha-mannosidase, 3.2.1.102 blood-group-substance endo-1,4-beta-galactosidase, 3.2.1.103 keratan-sulfate endo-1,4-beta-galactosidase, 3.2.1.104 steryl-beta-glucosidase, 3.2.1.105 3alpha(S)-strictosidine beta-glucosidase, 3.2.1.106 mannosyl-oligosaccharide glucosidase, 3.2.1.107 protein-glucosylgalactosylhydroxylysine glucosidase, 3.2.1.108 lactase, 3.2.1.109 endogalactosaminidase, 3.2.1.110 mucinaminylserine mucinaminidase, 3.2.1.111 1,3-alpha-L-fucosidase, 3.2.1.112 2-deoxyglucosidase, 3.2.1.113 mannosyl-oligosaccharide 1,2-alpha-mannosidase, 3.2.1.114 mannosyl-oligosaccharide 1,3-1,6-alpha-mannosidase, 3.2.1.115 branched-dextran exo-1,2-alpha-glucosidase, 3.2.1.116 glucan 1,4-alpha-maltotriohydrolase, 3.2.1.117 amygdalin beta-glucosidase, 3.2.1.118 prunasin beta-glucosidase, 3.2.1.119 vicianin beta-glucosidase, 3.2.1.120 oligoxyloglucan beta-glycosidase, 3.2.1.121 polymannuronate hydrolase, 3.2.1.122 maltose-6'-phosphate glucosidase, 3.2.1.123 endoglycosylceramidase, 3.2.1.124 3-deoxy-2-octulosonidase, 3.2.1.125 raucaffricine beta-glucosidase, 3.2.1.126 coniferin beta-glucosidase, 3.2.1.127 1,6-alpha-L-fucosidase, 3.2.1.128 glycyrrhizinate beta-glucuronidase, 3.2.1.129 endo-alpha-sialidase, 3.2.1.130 glycoprotein endo-alpha-1,2-mannosidase, 3.2.1.131 xylan alpha-1,2-glucuronosidase, 3.2.1.132 chitosanase, 3.2.1.133 glucan 1,4-alpha-maltohydrolase, 3.2.1.134 difructose-anhydride synthase, 3.2.1.135 neopullulanase, 3.2.1.136 glucuronoarabinoxylan endo-1,4-beta-xylanase, 3.2.1.137 mannan exo-1,2-1,6-alpha-mannosidase, 3.2.1.138 anhydrosialidase, 3.2.1.139 alpha-glucuronidase, 3.2.1.140 lacto-N-biosidase, 3.2.1.141 4-alpha-D-{(1->4)-alpha-D-glucano}trehalose trehalohydrolase, 3.2.1.142 limit dextrinase, 3.2.1.143 poly(ADP-ribose) glycohydrolase, 3.2.1.144 3-deoxyoctulosonase, 3.2.1.145 galactan 1,3-beta-galactosidase, 3.2.1.146 beta-galactofuranosidase, 3.2.1.147 thioglucosidase, 3.2.1.148 ribosylhomocysteinase, 3.2.1.149 beta-primeverosidase, 3.2.1.150 oligoxyloglucan reducing-end-specific cellobiohydrolase, 3.2.1.151 xyloglucan-specific endo-beta-1,4-glucanase, 3.2.1.152 mannosylglycoprotein endo-beta-mannosidase, 3.2.1.153 fructan beta-(2,1)-fructosidase, 3.2.1.154 fructan beta-(2,6)-fructosidase, 3.2.1.155 xyloglucan-specific exo-beta-1,4-glucanase, 3.2.1.156 oligosaccharide reducing-end xylanase, 3.2.1.157 iota-carrageenase 3.2.1.158 alpha-agarase, 3.2.1.159 alpha-neoagaro-oligosaccharide hydrolase, 3.2.1.160 xyloglucan-specific exo-beta-1,4-glucanase, 3.2.1.161 beta-apiosyl-beta-glucosidase, 3.2.1.162 lambda-carrageenase, 3.2.1.163 1,6-alpha-D-mannosidase, 3.2.1.164 galactan endo-1,6-beta-galactosidase, 3.2.1.165 exo-1,4-beta-D-glucosaminidase, or a combination thereof.

Other enzymes that are used in various embodiments of the methods described herein include, by way of non-limiting example, a sulfatase including, e.g., enzymes categorized as 3.1.6.X by BRENDA (the comprehensive Enzyme Information System) including 3.1.6.1 arylsulfatase, 3.1.6.2 steryl-sulfatase, 3.1.6.3 glycosulfatase, 3.1.6.4 N-acetylgalac-

tosamine-6-sulfatase, 3.1.6.5 sinigrin sulfohydrolase; myrosulfatase, 3.1.6.6 choline-sulfatase, 3.1.6.7 cellulose-polysulfatase, 3.1.6.8 cerebroside-sulfatase, 3.1.6.9 chondro-4-sulfatase, 3.1.6.10 chondro-6-sulfatase, 3.1.6.11 disulfo-glucosamine-6-sulfatase, 3.1.6.12 N-acetylgalactosamine-4-sulfatase, 3.1.6.13 iduronate-2-sulfatase, 3.1.6.14 N-acetylglucosamine-6-sulfatase, 3.1.6.15 N-sulfoglu-cosamine-3-sulfatase, 3.1.6.16 monomethyl-sulfatase, 3.1.6.17 D-lactate-2-sulfatase, 3.1.6.18 glucuronate-2-sulfa-tase, 3.10.1.1 N-sulfoglucosamine sulfohydrolase, or combi-nations thereof.

Certain enzymes that are used in various embodiments of the methods described herein include, by way of non-limiting example, a deacetylase, e.g., an exo-deacetylase, including, by way of non-limiting example, the alpha-glucosaminide N-acetyltransferase (2.3.1.78) or similar enzymes.

Certain enzymes that are used in various embodiments of the methods described herein include, by way of non-limiting example, a carbohydrate phosphatase including, e.g., 3.1.3.1 alkaline phosphatase, 3.1.3.2 acid phosphatase, 3.1.3.B2 dia-cylglycerol pyrophosphate phosphatase, 3.1.3.3 phospho-serine phosphatase, 3.1.3.4 phosphatidate phosphatase, 3.1.3.5 5'-nucleotidase, 3.1.3.6 3'-nucleotidase, 3.1.3.7 3'(2'), 5'-bisphosphate nucleotidase, 3.1.3.8 3-phytase, 3.1.3.9 glu-cose-6-phosphatase, 3.1.3.10 glucose-1-phosphatase, 3.1.3.11 fructose-bisphosphatase, 3.1.3.12 trehalose-phos-phatase, 3.1.3.13 bisphosphoglycerate phosphatase, 3.1.3.14 methylphosphothioglycerate phosphatase, 3.1.3.15 histidi-nol-phosphatase, 3.1.3.16 phosphoprotein phosphatase, 3.1.3.17 [phosphorylase]phosphatase, 3.1.3.18 phosphogly-colate phosphatase, 3.1.3.19 glycerol-2-phosphatase, 3.1.3.20 phosphoglycerate phosphatase, 3.1.3.21 glycerol-1-phosphatase, 3.1.3.22 mannitol-1-phosphatase, 3.1.3.23 sugar-phosphatase, 3.1.3.24 sucrose-phosphate phosphatase, 3.1.3.25 inositol-phosphate phosphatase, 3.1.3.26 4-phytase, 3.1.3.27 phosphatidylglycerophosphatase, 3.1.3.28 ADP-phosphoglycerate phosphatase, 3.1.3.29 N-acylneuraminate-9-phosphatase, 3.1.3.30 3'-phosphoadenylylsulfate 3'-phos-phatase, 3.1.3.31 nucleotidase, 3.1.3.32 polynucleotide 3'-phosphatase, 3.1.3.33 polynucleotide 5'-phosphatase, 3.1.3.34 deoxynucleotide 3'-phosphatase, 3.1.3.35 thymidy-late 5'-phosphatase, 3.1.3.36 phosphoinositide 5-phos-phatase, 3.1.3.37 sedoheptulose-bisphosphatase, 3.1.3.38 3-phosphoglycerate phosphatase, 3.1.3.39 streptomycin-6-phosphatase, 3.1.3.40 guanidinodeoxy-scyllo-inositol-4-phosphatase, 3.1.3.41 4-nitrophenylphosphatase, 3.1.3.42 [glycogen-synthase-D] phosphatase, 3.1.3.43 [pyruvate dehydrogenase (acetyl-transferring)]-phosphatase, 3.1.3.44 [acetyl-CoA carboxylase]-phosphatase, 3.1.3.45 3-deoxy-manno-octulosonate-8-phosphatase, 3.1.3.46 fructose-2,6-bisphosphate 2-phosphatase, 3.1.3.47 [hydroxymethylglu-taryl-CoA reductase (NADPH)]-phosphatase, 3.1.3.48 protein-tyrosine-phosphatase, 3.1.3.49 [pyruvate kinase]-phosphatase, 3.1.3.50 sorbitol-6-phosphatase, 3.1.3.51 doli-chyl-phosphatase, 3.1.3.52 [3-methyl-2-oxobutanoate dehy-drogenase (2-methylpropanoyl-transferring)]-phosphatase, 3.1.3.53 [myosin-light-chain] phosphatase, 3.1.3.54 fruc-tose-2,6-bisphosphate 6-phosphatase, 3.1.3.55 caldesmon-phosphatase, 3.1.3.56 inositol-polyphosphate 5-phosphatase, 3.1.3.57 inositol-1,4-bisphosphate 1-phosphatase, 3.1.3.58 sugar-terminal-phosphatase, 3.1.3.59 alkylacetylglycero-phosphatase, 3.1.3.60 phosphoenolpyruvate phosphatase, 3.1.3.61 inositol-1,4,5-trisphosphate 1-phosphatase, 3.1.3.62 multiple inositol-polyphosphate phosphatase, 3.1.3.63 2-car-boxy-D-arabinitol-1-phosphatase, 3.1.3.64 phosphatidyli-nositol-3-phosphatase, 3.1.3.65 inositol-1,3-bisphosphate 3-phosphatase, 3.1.3.66 phosphatidylinositol-3,4-bisphos-phate 4-phosphatase, 3.1.3.67 phosphatidylinositol-3,4,5-trisphosphate 3-phosphatase, 3.1.3.68 2-deoxyglucose-6-phosphatase, 3.1.3.69 glucosylglycerol 3-phosphatase, 3.1.3.70 mannosyl-3-phosphoglycerate phosphatase, 3.1.3.71 2-phosphosulfolactate phosphatase, 3.1.3.72 5-phytase, 3.1.3.73 alpha-ribazole phosphatase, 3.1.3.74 pyridoxal phosphatase, 3.1.3.75 phosphoethanolamine/phos-phocholine phosphatase, 3.1.3.76 lipid-phosphate phos-phatase, 3.1.3.77 acireductone synthase, 3.1.3.78 phosphati-dylinositol-4,5-bisphosphate 4-phosphatase, or 3.1.3.79 mannosylfructose-phosphate phosphatase, or a combination thereof

In some embodiments, processes described herein include incubation and digestion with a first enzyme to clear a specific non-reducing end structure, incubation and digestion with a second enzyme. In certain embodiments, this multi-enzyme approach is useful in order to reduce the background. For example, in MPS II treating the sample with an iduronidase and/or glucuronidase to clear all non-sulfated non-reducing end uronic acids (this enzyme will not cleave sulfated idu-ronic acids) before 2-O sulfatase treatment. This approach will clear all non-sulfated non-reducing end uronic acids so that upon desulfation with the 2-O sulfatase the newly releas-able uronic acids will be those that were previously sulfated (and therefore resistant to the action of the iduronidase and/or glucuronidase).

Glycan Residual Compounds:

Glycan residual compounds detected, measured, analyzed, and/or otherwise characterized according to any process described herein include any suitable glycan residue that is liberated from the non-reducing end of a glycan (e.g., a gly-can obtained from a biological sample of an individual). In specific instances, glycan residual compounds including, e.g., oligosaccharides, monosaccharides, sulfate, phosphate, sialic acid, acetate, or the like.

Specific glycan residual compounds useful in any process herein are described in Tables 1-4.

In some embodiments, the generated biomarker is a glycan residual compound. In some embodiments, the glycan residual compound is a monosaccharide. In certain embodi-ments, the glycan residual compound is sulfate, phosphate, acetate, or a combination thereof. In certain embodiments, the glycan residual compound has a molecular weight of less than 2000 g/mol, less than 1500 g/mol, less than 1000 g/mol, less than 500 g/mol, less than 400 g/mol, less than 300 g/mol, less than 260 g/mol, less than 200 g/mol, less than 100 g/mol, or the like (e.g., prior to tagging with any detectable label that may be included in a process described herein).

Disorders:

In certain embodiments, a disorder associated with abnor-mal glycan accumulation includes a disorder associated therewith is caused by an abnormally functioning glycan degradation enzyme. In various embodiments, the abnor-mally functioning glycan degradation enzyme functions abnormally as a result of being present in an abnormally low amount, functioning improperly, or a combination thereof. For example, an abnormally functioning glycan degradation enzyme functions abnormally as a result of being present in an amount of less than 50%, less than 40%, less than 30%, less than 20%, less than 10%, or less than 5% than is present in an individual with normal amounts of the glycan degradation enzyme (e.g., an individual in a non-diseased, normal, or wild type state). In further or alternative embodiments, abnormally functioning glycan degradation enzymes are present in a nor-mal amount, but do not function properly in degrading gly-cans. For example, such enzymes may be have amino acid

substitutions in the sequences thereof that reduce or eliminate the glycan degradative properties of the enzyme.

MPS I is a human genetic disease caused by a deficiency in the lysosomal enzyme L-iduronidase. This enzyme is required in the lysosome to degrade glycans that contain iduronic acid. Due to this enzymatic deficiency, glycans with an iduronic acid on the non-reducing end accumulate to high levels (including heparan sulfate and dermatan sulfate). In certain embodiments, using the method described herein, MPS I is diagnosed in an individual from a biological sample taken therefrom. For example, in some embodiments, a biological sample is optionally placed into a defined MW cut off spin column (retains large molecules when spun), optionally washed (e.g., with water or buffer) to remove free monosaccharides, then treated with an iduronidase (e.g., to liberate a glycan residual compound iduronic acid). In certain embodiments, after incubation, the liberated iduronic acid is isolated, e.g., by washing the free monosaccharide through the defined MW cut off membrane (or other methods). In some of such embodiments, the monosaccharide would be in the flow through. The isolated monosaccharide solution is optionally dried or otherwise treated to concentrate the sample and subsequently analyzed for iduronic acid content by any suitable analytical technique (e.g., HPLC, MS, GC, or the like with or without chemical or enzymatic derivatization before detection). This method can be used to detect MPS I disease, measure disease severity, or to measure response to therapy.

MPS II is a human genetic disease caused by a deficiency in the lysosomal enzyme 2-sulfatase. This enzyme is required in the lysosome to degrade glycans that contain 2-O sulfated uronic acids. Due to this enzymatic deficiency, glycans with a 2-sulfated uronic acid on the non-reducing end accumulate to high levels (including heparan sulfate and dermatan sulfate). In certain embodiments, using the method described herein, MPS II is diagnosed in an individual from a biological sample taken therefrom. For example, in some embodiments, a biological sample is optionally placed in to a defined MW cut off spin column (retains large molecules when spun), optionally washed (e.g., with 1 or more volumes of water or buffer to remove free sulfate), and treated with a 2-sulfatase (e.g., to liberate a glycan residual compound sulfate). In some embodiments, after incubation, the liberated sulfate is optionally isolated by washing the free monosaccharide (e.g., through a defined MW cut off membrane or by any other suitable method). In some of such embodiments, the free sulfate is in the flow through. In certain embodiments, the resulting isolated solution is optionally dried or otherwise treated to concentrate the sample and subsequently analyzed for sulfate content by any suitable analytical technique (e.g., HPLC, MS, GC, pH detection, or the like with or without chemical or enzymatic derivatization before detection). This method can be used to detect MPS II disease, measure disease severity, or to measure response to therapy. In other exemplary embodiments, following treatment with a 2-sulfatase, the resulting 2-O desulfated non-reducing end uronic acid residues is optionally liberated with an iduronidase or glucuronidase. In some of such embodiments, the resulting liberated monosaccharide is optionally isolated, e.g., by washing free monosaccharide (e.g., through the defined MW cut off membrane or any other suitable method). In some of such embodiments, free iduronic or glucuronic acid is in the flow through. In certain embodiments, the resulting isolated solution is optionally dried or otherwise treated to concentrate the sample and subsequently analyzed for monosaccharide content by any suitable analytical technique (e.g., HPLC, MS, GC, or the like with or without chemical or enzymatic derivatization before detection). This method can be used to detect MPS II disease, measure disease severity, or to measure response to therapy.

MPS IIIA is a human genetic disease caused by a deficiency in the lysosomal enzyme N-sulfatase. This enzyme is required in the lysosome to degrade glycans that contain N-sulfated glucosamine residues. Due to this enzymatic deficiency, glycans with N-sulfated glucosamine residues on the non-reducing end accumulate to high levels (including heparan sulfate). In certain embodiments, using the method described herein, MPS IIIA is diagnosed in an individual from a biological sample taken therefrom. For example, in some embodiments, a biological sample is optionally placed in to a defined MW cut off spin column (retains large molecules when spun), optionally washed (e.g., with 1 or more volumes of water or buffer) to remove free sulfate, and treated with an N-sulfatase. In certain embodiments, after incubation, the liberated sulfate is optionally isolated, e.g., by washing the free monosaccharide (such as through a defined MW cut off membrane or any other suitable method). In some of such embodiments, free sulfate for detection and/or quantitation in the flow through. In certain embodiments, the resulting isolated solution is optionally dried or otherwise treated to concentrate the sample and subsequently analyzed for sulfate content by any suitable analytical technique (e.g., HPLC, MS, GC, pH detection, or the like with or without chemical or enzymatic derivatization before detection). This method can be used to detect MPS IIIA disease, measure disease severity, or to measure response to therapy. In further or alternative embodiments, following treatment with an N-sulfatase, the resulting N-desulfated non-reducing end glucosamine residues is optionally liberated with a hexosaminidase. In some of such embodiments, liberated monosaccharide is optionally isolated (e.g., by washing the free monosaccharide, such as through the defined MW cut off membrane or any other suitable method). In some of such embodiments, free glucosamine for detection and/or quantitation is present in the flow through. In certain embodiments, the resulting isolated solution is optionally dried or otherwise treated to concentrate the sample and subsequently analyzed for monosaccharide content by any suitable analytical technique (e.g., HPLC, MS, GC, or the like with or without chemical or enzymatic derivatization before detection). This method can be used to detect MPS IIIA disease, measure disease severity, or to measure response to therapy.

As discussed above, in certain embodiments, using the method described herein, MPS IIIA is diagnosed in an individual from a biological sample taken therefrom. For example, in some embodiments, a biological sample is optionally placed in to a defined MW cut off spin column (retains large molecules when spun), optionally washed (e.g., with 1 or more volumes of water or buffer) to remove free monosaccharide, and treated with an N-sulfo glucosaminidase such as a heparin lyase. In some embodiments, liberated sulfated monosaccharide is optionally isolated, e.g., by washing the free monosaccharide (such as through the defined MW cut off membrane or by any other suitable method). In some of such embodiments, free N-sulfated glucosamine for detection and/or quantitation is present in the flow through. In certain embodiments, the resulting isolated solution is optionally dried or otherwise treated to concentrate the sample and subsequently analyzed for monosaccharide content by any suitable analytical technique (e.g., HPLC, MS, GC, or the like with or without chemical or enzymatic derivatization before detection). This method can be used to detect MPS IIIA disease, measure disease severity, or to measure response to therapy.

As discussed above, in certain embodiments, using the method described herein, MPS IIIA is diagnosed in an individual from a biological sample taken therefrom. For example, in some embodiments, a biological sample is optionally placed in to a defined MW cut off spin column (retains large molecules when spun), optionally washed (e.g., with 1 or more volumes of water or buffer) to remove free monosaccharide, and treated with an N-sulfatase. In certain embodiments, the resulting glycan is subsequently treated such that the N-desulfated non-reducing end glucosamine residues is acetylated (e.g., with an N-acetyl transferase) and subsequently liberated with a hexosaminidase. In some of such embodiments, the resulting liberated monosaccharide is optionally isolated, e.g., by washing the free monosaccharide (e.g., through a defined MW cut off membrane or any other suitable methods). In some of such embodiments, free N-acetyl glucosamine for detection and/or quantitation is present in the flow through. In certain embodiments, the resulting isolated composition is optionally dried or otherwise treated to concentrate the sample and subsequently analyzed for monosaccharide content by any suitable analytical technique (e.g., HPLC, MS, GC, or the like with or without chemical or enzymatic derivatization before detection). This method can be used to detect MPS IIIA disease, measure disease severity, or to measure response to therapy.

MPS IIIB is a human genetic disease caused by a deficiency in the enzyme N-acetyl glucosaminidase. This enzyme is required in the lysosome to degrade glycans that contain N-acetyl glucosamine residues. Due to this enzymatic deficiency, glycans with a N-acetyl glucosamine residue on the non-reducing end accumulate to high levels (including heparan sulfate). In certain embodiments, using the method described herein, MPS IIIB is diagnosed in an individual from a biological sample taken therefrom. For example, in some embodiments, a biological sample is optionally placed in to a defined MW cut off spin column (retains large molecules when spun), optionally washed (e.g., with 1 or more volumes of water or buffer to remove free N-acetyl glucosamine), and treated with a-acetyl glucosaminidase or a heparin lyase (e.g., to liberate a glycan residual compound N-acetyl glucosamine). In some embodiments, after incubation, the liberated N-acetyl glucosamine is optionally isolated by washing the free monosaccharide (e.g., through a defined MW cut off membrane or by any other suitable method). In some of such embodiments, the free monosaccharide is in the flow through. In certain embodiments, the resulting isolated solution is optionally dried or otherwise treated to concentrate the sample and subsequently analyzed for monosaccharide content by any suitable analytical technique (e.g., HPLC, MS, GC, pH detection, or the like with or without chemical or enzymatic derivatization before detection). This method can be used to detect MPS IIIB disease, measure disease severity, or to measure response to therapy.

As discussed above, in certain embodiments, using the method described herein, MPS IIIA is diagnosed in an individual from a biological sample taken therefrom. For example, in some embodiments, a biological sample is optionally placed in to a defined MW cut off spin column (retains large molecules when spun), optionally washed (e.g., with 1 or more volumes of water or buffer) to remove free acetate, and treated with a deacetylase. The liberated acetate is optionally isolated, e.g., by washing the free acetate (such as through the defined MW cut off membrane or any other suitable method). In some of such embodiments, the free acetate for detection and/or quantitation is present the flow through. In some embodiments, the resulting isolated solution is optionally dried or otherwise treated to concentrate the sample and subsequently analyzed for acetate content by any suitable analytical technique (e.g., HPLC, MS, GC, pH detection, or the like with or without chemical or enzymatic derivatization before detection). This method can be used to detect MPS IIIB disease, measure disease severity, or to measure response to therapy.

MPS IIIC is a human genetic disease caused by a deficiency in the enzyme N-acetyltransferase. This enzyme is required in the lysosome to degrade glycans that contain glucosamine residues. Due to this enzymatic deficiency, glycans with a glucosamine residue on the non-reducing end accumulate to high levels (including heparan sulfate). In certain embodiments, using the method described herein, MPS IIIC is diagnosed in an individual from a biological sample taken therefrom. For example, in some embodiments, a biological sample is optionally placed in to a defined MW cut off spin column (retains large molecules when spun), optionally washed (e.g., with 1 or more volumes of water or buffer to remove free glucosamine), and treated with a hexosaminidase or heparin lyase (e.g., to liberate a glycan residual compound glucosamine). In some embodiments, after incubation, the liberated glucosamine is optionally isolated by washing the free glucosamine (e.g., through a defined MW cut off membrane or by any other suitable method). In some of such embodiments, the free glucosamine for detection and/or quantitation is present in the flow through. In certain embodiments, the resulting isolated solution is optionally dried or otherwise treated to concentrate the sample and subsequently analyzed for monosaccharide content by any suitable analytical technique (e.g., HPLC, MS, GC, pH detection, or the like with or without chemical or enzymatic derivatization before detection). This method can be used to detect MPS IIIC disease, measure disease severity, or to measure response to therapy.

As discussed above, in certain embodiments, using the method described herein, MPS IIIC is diagnosed in an individual from a biological sample taken therefrom. For example, in some embodiments, a biological sample is optionally placed in to a defined MW cut off spin column (retains large molecules when spun), optionally washed (e.g., with 1 or more volumes of water or buffer to remove free glucosamine and/or N-acetyl glucosamine), and treated with a glucosamine N-acetyltransferase followed by a hexosaminidase (e.g., to liberate a glycan residual compound N-acetyl glucosamine). In some embodiments, after incubation, the liberated N-acetyl glucosamine is optionally isolated by washing the free N-acetyl glucosamine (e.g., through a defined MW cut off membrane or by any other suitable method). In some of such embodiments, the free N-acetyl glucosamine for detection and/or quantitation is present in the flow through. In certain embodiments, the resulting isolated solution is optionally dried or otherwise treated to concentrate the sample and subsequently analyzed for monosaccharide content by any suitable analytical technique (e.g., HPLC, MS, GC, pH detection, or the like with or without chemical or enzymatic derivatization before detection). This method can be used to detect MPS IIIC disease, measure disease severity, or to measure response to therapy.

MPS IIID is a human genetic disease caused by a deficiency in the enzyme glucosamine 6-O sulfatase. This enzyme is required in the lysosome to degrade glycans that contain 6-O-sulfated glucosamine residues. Due to this enzymatic deficiency, glycans with a 6-O-sulfated N-acetyl glucosamine residue on the non-reducing end accumulate to high levels (including heparan sulfate). In certain embodiments, using the method described herein, MPS IIIC is diagnosed in an individual from a biological sample taken therefrom. For

example, in some embodiments, a biological sample is optionally placed in to a defined MW cut off spin column (retains large molecules when spun), optionally washed (e.g., with 1 or more volumes of water or buffer to remove free sulfate), and treated with a 6-O-sulfatase (e.g., to liberate a glycan residual compound sulfate). In some embodiments, after incubation, the liberated sulfate is optionally isolated by washing the free sulfate (e.g., through a defined MW cut off membrane or by any other suitable method). In some of such embodiments, the free sulfate for detection and/or quantitation is present in the flow through. In certain embodiments, the resulting isolated solution is optionally dried or otherwise treated to concentrate the sample and subsequently analyzed for sulfate content by any suitable analytical technique (e.g., HPLC, MS, GC, pH detection, or the like with or without chemical or enzymatic derivatization before detection). This method can be used to detect MPS HID disease, measure disease severity, or to measure response to therapy.

As discussed above, in certain embodiments, using the method described herein, MPS IIID is diagnosed in an individual from a biological sample taken therefrom. For example, in some embodiments, a biological sample is optionally placed in to a defined MW cut off spin column (retains large molecules when spun), optionally washed (e.g., with 1 or more volumes of water or buffer to remove free sulfate and/or N-acetyl glucosamine), and treated with a 6-O-sulfatase and a hexosaminidase (e.g., to liberate a glycan residual compound N-acetyl glucosamine). In some embodiments, after incubation, the liberated N-acetyl glucosamine is optionally isolated by washing the free N-acetyl glucosamine (e.g., through a defined MW cut off membrane or by any other suitable method). In some of such embodiments, the free monosaccharide for detection and/or quantitation is present in the flow through. In certain embodiments, the resulting isolated solution is optionally dried or otherwise treated to concentrate the sample and subsequently analyzed for monosaccharide content by any suitable analytical technique (e.g., HPLC, MS, GC, or the like with or without chemical or enzymatic derivatization before detection). This method can be used to detect MPS IIID disease, measure disease severity, or to measure response to therapy.

As discussed above, in certain embodiments, using the method described herein, MPS IIID is diagnosed in an individual from a biological sample taken therefrom. For example, in some embodiments, a biological sample is optionally placed in to a defined MW cut off spin column (retains large molecules when spun), optionally washed (e.g., with 1 or more volumes of water or buffer to remove free sulfate and/or N-acetyl glucosamine 6-O sulfate), and treated with a hexosaminidase or heparin lyase (e.g., to liberate a glycan residual compound N-acetyl glucosamine 6-O sulfate). In some embodiments, after incubation, the liberated N-acetyl glucosamine 6-O sulfate is optionally isolated by washing the free N-acetyl glucosamine 6-O sulfate (e.g., through a defined MW cut off membrane or by any other suitable method). In some of such embodiments, the free monosaccharide for detection and/or quantitation is present in the flow through. In certain embodiments, the resulting isolated solution is optionally dried or otherwise treated to concentrate the sample and subsequently analyzed for monosaccharide content by any suitable analytical technique (e.g., HPLC, MS, GC, pH detection, or the like with or without chemical or enzymatic derivatization before detection). This method can be used to detect MPS HID disease, measure disease severity, or to measure response to therapy.

MPS IVA is a human genetic disease caused by a deficiency in the enzyme lysosomal enzyme galactose/N-acetyl galactosamine 6-O sulfatase. This enzyme is required in the lysosome to degrade glycans that contain 6-O-sulfated galactose and 6-O sulfated N-acetyl galactosamine residues. Due to this enzymatic deficiency, glycans with 6-O-sulfated galactose and 6-O sulfated N-acetyl galactosamine residues on the non-reducing end accumulate to high levels (including chondroitin and keratan sulfate). In certain embodiments, using the method described herein, MPS IVA is diagnosed in an individual from a biological sample taken therefrom. For example, in some embodiments, a biological sample is optionally placed in to a defined MW cut off spin column (retains large molecules when spun), optionally washed (e.g., with 1 or more volumes of water or buffer to remove free monosaccharide), and treated with a galactose 6-O-sulfatase and/or an N-acetyl galactosamine 6-O sulfatase and a galactosidase and/or hexosaminidase (e.g., to liberate a glycan residual compound Gal and/or GalNAc). In some embodiments, after incubation, the liberated monosaccharide is optionally isolated by washing the free monosaccharide (e.g., through a defined MW cut off membrane or by any other suitable method). In some of such embodiments, the free monosaccharide for detection and/or quantitation is present in the flow through. In certain embodiments, the resulting isolated solution is optionally dried or otherwise treated to concentrate the sample and subsequently analyzed for monosaccharide content by any suitable analytical technique (e.g., HPLC, MS, GC, or the like with or without chemical or enzymatic derivatization before detection). This method can be used to detect MPS IVA disease, measure disease severity, or to measure response to therapy.

As discussed above, in certain embodiments, using the method described herein, MPS IVA is diagnosed in an individual from a biological sample taken therefrom. For example, in some embodiments, a biological sample is optionally placed in to a defined MW cut off spin column (retains large molecules when spun), optionally washed (e.g., with 1 or more volumes of water or buffer to remove free sulfate), and treated with a 6-O-sulfatase capable of desulfating 6-O-sulfated galactose and/or 6-O sulfated N-acetyl galactosamine residues (e.g., to liberate a glycan residual compound sulfate). In some embodiments, after incubation, the liberated sulfate is optionally isolated by washing the free sulfate (e.g., through a defined MW cut off membrane or by any other suitable method). In some of such embodiments, the free sulfate for detection and/or quantitation is present in the flow through. In certain embodiments, the resulting isolated solution is optionally dried or otherwise treated to concentrate the sample and subsequently analyzed for sulfate content by any suitable analytical technique (e.g., HPLC, MS, GC, pH detection, or the like with or without chemical or enzymatic derivatization before detection). This method can be used to detect MPS IVA disease, measure disease severity, or to measure response to therapy.

MPS IVB is a human genetic disease caused by a deficiency in the enzyme lysosomal β-galactosidase. This enzyme is required in the lysosome to degrade glycans that contain galactose residues. Due to this enzymatic deficiency, glycans with β-galactose residues on the non-reducing end accumulate to high levels (including keratan sulfate and other glycans). In certain embodiments, using the method described herein, MPS IVB is diagnosed in an individual from a biological sample taken therefrom. For example, in some embodiments, a biological sample is optionally placed in to a defined MW cut off spin column (retains large molecules when spun), optionally washed (e.g., with 1 or more volumes of water or buffer to remove free monosaccharide), and treated with a galactosidase (e.g., to liberate a glycan

residual compound Gal). In some embodiments, after incubation, the liberated monosaccharide is optionally isolated by washing the free monosaccharide (e.g., through a defined MW cut off membrane or by any other suitable method). In some of such embodiments, the free monosaccharide for detection and/or quantitation is present in the flow through. In certain embodiments, the resulting isolated solution is optionally dried or otherwise treated to concentrate the sample and subsequently analyzed for monosaccharide content by any suitable analytical technique (e.g., HPLC, MS, GC, or the like with or without chemical or enzymatic derivatization before detection). This method can be used to detect MPS IVB disease, measure disease severity, or to measure response to therapy.

MPS VI is a human genetic disease caused by a deficiency in the enzyme 4-O sulfatase that desulfates N-acetyl galactosamine. This enzyme is required in the lysosome to degrade glycans that contain 4-O-sulfated N-acetyl galactosamine residues. Due to this enzymatic deficiency, glycans with 4-O-sulfated N-acetyl galactosamine residues on the non-reducing end accumulate to high levels (including chondroitin sulfate). In certain embodiments, using the method described herein, MPS VI is diagnosed in an individual from a biological sample taken therefrom. For example, in some embodiments, a biological sample is optionally placed in to a defined MW cut off spin column (retains large molecules when spun), optionally washed (e.g., with 1 or more volumes of water or buffer to remove free sulfate), and treated with a 4-O-sulfatase that can desulfate 4-O-sulfated N-acetyl galactosamine residues (e.g., to liberate a glycan residual compound sulfate). In some embodiments, after incubation, the liberated sulfate is optionally isolated by washing the free sulfate (e.g., through a defined MW cut off membrane or by any other suitable method). In some of such embodiments, the free sulfate for detection and/or quantitation is present in the flow through. In certain embodiments, the resulting isolated solution is optionally dried or otherwise treated to concentrate the sample and subsequently analyzed for sulfate content by any suitable analytical technique (e.g., HPLC, MS, GC, pH detection, or the like with or without chemical or enzymatic derivatization before detection). This method can be used to detect MPS VI disease, measure disease severity, or to measure response to therapy.

As discussed above, in certain embodiments, using the method described herein, MPS VI is diagnosed in an individual from a biological sample taken therefrom. For example, in some embodiments, a biological sample is optionally placed in to a defined MW cut off spin column (retains large molecules when spun), optionally washed (e.g., with 1 or more volumes of water or buffer to remove free N-acetyl galactosamine), and treated with a 4-O-sulfatase that is capable of desulfating 4-O-sulfated N-acetyl galactosamine residues then treated with a hexosaminidase (e.g., to liberate a glycan residual compound N-acetyl galactosamine). In some embodiments, after incubation, the liberated N-acetyl galactosamine is optionally isolated by washing the free monosaccharide (e.g., through a defined MW cut off membrane or by any other suitable method). In some of such embodiments, the free monosaccharide for detection and/or quantitation is present in the flow through. In certain embodiments, the resulting isolated solution is optionally dried or otherwise treated to concentrate the sample and subsequently analyzed for monosaccharide content by any suitable analytical technique (e.g., HPLC, MS, GC, or the like with or without chemical or enzymatic derivatization before detection). This method can be used to detect MPS VI disease, measure disease severity, or to measure response to therapy.

MPS VII is a human genetic disease caused by a deficiency in the lysosomal enzyme beta-glucuronidase. This enzyme is required in the lysosome to degrade glycans that contain glucuronic acid residues. Due to this enzymatic deficiency, glycans with glucuronic acid residues on the non-reducing end accumulate to high levels (including chondroitin sulfate, heparan sulfate and others). In certain embodiments, using the method described herein, MPS VII is diagnosed in an individual from a biological sample taken therefrom. For example, in some embodiments, a biological sample is optionally placed in to a defined MW cut off spin column (retains large molecules when spun), optionally washed (e.g., with 1 or more volumes of water or buffer to remove free glucuronic acid), and treated with a glucuronidase (e.g., to liberate a glycan residual compound glucuronic acid). In some embodiments, after incubation, the liberated monosaccharide is optionally isolated by washing the free monosaccharide (e.g., through a defined MW cut off membrane or by any other suitable method). In some of such embodiments, the free monosaccharide for detection and/or quantitation is present in the flow through. In certain embodiments, the resulting isolated solution is optionally dried or otherwise treated to concentrate the sample and subsequently analyzed for monosaccharide content by any suitable analytical technique (e.g., HPLC, MS, GC, pH detection, or the like with or without chemical or enzymatic derivatization before detection). This method can be used to detect MPS VII disease, measure disease severity, or to measure response to therapy.

Methods described herein can also be used to define the relative presence of different glycan classes.

Fabry Disease is a human genetic disease caused by a deficiency in the lysosomal α-galactosidase. Due to this enzymatic deficiency, glycans with non-reducing end terminal α-galactose residues are abundant. In certain embodiments, using the method described herein, Fabry Disease is diagnosed in an individual from a biological sample taken therefrom. For example, in some embodiments, a biological sample is optionally placed in to a defined MW cut off spin column (retains large molecules when spun), optionally washed (e.g., with 1 or more volumes of water or buffer to remove free monosaccharide), and treated with a galactosidase that is capable of liberating a non-reducing end monosaccharide (e.g., to liberate a glycan residual compound). In some embodiments, after incubation, the liberated glycan residual compound is optionally isolated by washing the free glycan residual compound (e.g., through a defined MW cut off membrane or by any other suitable method). In some of such embodiments, the free glycan residual compound for detection and/or quantitation is present in the flow through. In certain embodiments, the resulting isolated solution is optionally dried or otherwise treated to concentrate the sample and subsequently analyzed for glycan residual compound content by any suitable analytical technique (e.g., HPLC, MS, GC, pH detection, or the like with or without chemical or enzymatic derivatization before detection). This method can be used to detect Fabry Disease, measure disease severity, or to measure response to therapy.

In some embodiments, as described in Table 1, other enzymes and processes are optionally utilized to diagnose other lysosomal storage diseases (LSDs). As described in the table, the appropriate enzyme(s) can be selected as appropriate for the specific disease. Oncology—Melanoma and Neuroblastoma via Sialic Acid

A hallmark of cancer is altered glycosylation. The changes in glycosylation are a reflection of changes in enzymes and factors that regulate the biosynthesis, turnover, presentation, stability, solubility, and degradation of glycans. Many of

these changes result in glycans being produced that have altered structures. The methods described here are utilized in various embodiments to evaluate those structural changes (e.g., measure abnormal glycan accumulation) that are present on the non-reducing end of the glycans present in individuals suffering from a cancerous disease.

Some examples of cancerous diseases suitable for diagnosis and/or monitoring therapy according to methods described herein include, by way of non-limiting example, melanoma and neuroblastoma. In some instances, such cancers have alterations in the biosynthesis, turnover, presentation, stability, solubility, or degradation of gangliosides. In some instances, these sialic acid modified glycolipids are detected and/or otherwise characterized or analyzed in a biological sample (e.g., serum) of patients with these tumor types. In some embodiments, the abundance of the heterogeneous population of gangliosides is quantified to measuring sialic acid or other glycan residual released from gangliosides in the blood.

Due to this enzymatic alteration, gangliosides and other glycans are present in the body at high levels. In certain embodiments, using the method described herein, cancer (e.g., melanoma or neuroblastoma) is diagnosed in an individual from a biological sample taken therefrom. For example, in some embodiments, a biological sample is optionally placed in to a defined MW cut off spin column (retains large molecules when spun), optionally washed (e.g., with 1 or more volumes of water or buffer to remove free sialic acid), and treated with a sialidase that can liberate sialic acid (e.g., to liberate a glycan residual compound sialic acid). In some embodiments, after incubation, the liberated sialic acid is optionally isolated by washing the free sialic acid (e.g., through a defined MW cut off membrane or by any other suitable method). In some of such embodiments, the free sialic acid for detection and/or quantitation is present in the flow through. In certain embodiments, the resulting isolated solution is optionally dried or otherwise treated to concentrate the sample and subsequently analyzed for sialic acid content by any suitable analytical technique (e.g., HPLC, MS, GC, pH detection, or the like with or without chemical or enzymatic derivatization before detection). This method can be used to detect cancer (e.g., melanoma or neuroblastoma) disease, measure disease severity, or to measure response to therapy.

Oncology—Myeloma Via Heparan Sulfate Nonreducing Ends

An example of a human cancer that is diagnosed and/or monitored according to the methods described herein (i.e., by analyzing with such a method the altered degradation of a glycan) is multiple myeloma. In certain instances, multiple myeloma commonly produces heparanase. Heparanase is an endoglycosidase that cleaved heparan sulfate into smaller fragments, exposing novel non-reducing end structures. In certain embodiments described herein, the presence of these novel non-reducing end structures are detected using any method described herein (e.g., by incubating a biological sample with various glycosidases or sulfatases to detect the presence of novel glycan non-reducing ends).

Due to this enzymatic alteration, glycans (including heparan sulfate and others) are present in the body at high levels. In certain embodiments, using the method described herein, cancer (e.g., multiple myeloma) is diagnosed in an individual from a biological sample taken therefrom. For example, in some embodiments, a biological sample is optionally placed in to a defined MW cut off spin column (retains large molecules when spun), optionally washed (e.g., with 1 or more volumes of water or buffer to remove free monosaccharides and/or sulfate), and treated with a sulfatase, iduronidase, glucuronidase, hexosaminidase, or lyase that is capable of liberating a non-reducing end monosaccharide or sulfate. In some embodiments, after incubation, the liberated glycan residual compound is optionally isolated by washing the free glycan residual compound (e.g., through a defined MW cut off membrane or by any other suitable method). In some of such embodiments, the free glycan residual compound for detection and/or quantitation is present in the flow through. In certain embodiments, the resulting isolated solution is optionally dried or otherwise treated to concentrate the sample and subsequently analyzed for glycan residual compound content by any suitable analytical technique (e.g., HPLC, MS, GC, pH detection, or the like with or without chemical or enzymatic derivatization before detection). This method can be used to detect cancer (e.g., multiple myeloma) disease, measure disease severity, or to measure response to therapy.

Oncology—Adenocarcinoma

Adenocarcinoma is associated with changes in glycosylation including increased sialylation and fucosylation. The described method can be used to measure disease by analyzing glycans (total or purified or enriched for specific glycan classes) from a patient for the amount of nonreducing end terminal sialic acid or fucose, by measuring the release of these glycan residuals after treatment with a sialidase or fucosidase.

Other Applications

As described in Tables 1-4, various diseases associated with changes in glycosylation are optionally diagnosed and/or monitored according to methods described herein. Various disorders include, by way of non-limiting example, lysosomal storage disease, cancer, neurological disease (dementia, Alzheimer's, etc), liver disease, bone disease, infectious diseases, and the like.

Provided herein are methods of diagnosing individuals (including, e.g., a disease state or the severity of a disease states) with a lysosomal storage disease (LSD) or methods of monitoring the treatment of a lysosomal storage disease (LSD). Provided in Table 1 are specific embodiments of disease that are optionally diagnosed and/or monitored according to various embodiments described herein. Table 1 also illustrates various non-limiting embodiments of specific enzyme(s) that are optionally utilized to treat a biological sample from an individual suffering from or suspected (e.g., through a pre- or preliminary screening process) of suffering from an LSD. Moreover, Table 1 further illustrates various glycan residual compounds that are liberated in various embodiments described herein, such liberated glycan residual compounds optionally being detected and/or measured in order to diagnose and/or monitor a lysosomal storage disease (LSD).

TABLE 1

Exemplary LSD Uses

Disease	Non-Reducing End Structure	Primary Releasing Enzyme	Secondary Releasing Enzyme	Glycan Residual Compound
MPS I	IdoA	iduronidase		IdoA
MPS II	IdoA-2-O sufate and GlcA-2-O sufate	2-sulfatase		Sulfate
MPS II	IdoA-2-O sufate and GlcA-2-O sufate	2-sulfatase	Iduronidase and/or glucuronidase	IdoA and/or GlcA
MPS IIIA	GlcN—N-sulfate	N-sulfatase		Sulfate
MPS IIIA	GlcN—N-sulfate	N-sulfatase	hexosaminidase	GlcN
MPS IIIA	GlcN—N-sulfate	N-sulfatase	Heparin lyase	GlcN
MPS IIIA	GlcN—N-sulfate	N-sulfatase	N-acetyl transferase and hexosaminidase	GlcNAc
MPS IIIA	GlcN—N-sulfate	Heparin lyase		GlcN—N-sulfate
MPS IIIB	GlcNAc	hexosaminidase		GlcNAc
MPS IIIB	GlcNAc	Deacetylase		acetate
MPS IIIB	GlcNAc	Heparin lyase		GlcNAc
MPS IIIC	GlcNAc-6-O sulfate	6-O sulfatase		Sulfate
MPS IIIC	GlcNAc-6-O sulfate	6-O sulfatase	hexosaminidase	GlcNAc
MPS IIIC	GlcNAc-6-O sulfate	6-O sulfatase	Heparin lyase	GlcNAc
MPS IIIC	GlcNAc-6-O sulfate	Heparin lyase		GlcNAc-6-O sulfate
MPS IIID	GlcN	hexosaminidase		GlcN
MPS IIID	GlcN	Heparin lyase		GlcN
MPS IIID	GlcN	N-acetyl transferase	hexosaminidase	GlcNAc
MPS IVA	Gal-6-O sulfate and GalNAc-6-O sulfate	6-O sulfatase		Sulfate
MPS IVA	Gal-6-O sulfate and GalNAc-6-O sulfate	galactosidase		Gal-6-O sulfate
MPS IVA	Gal-6-O sulfate and GalNAc-6-O sulfate	N-acetyl galactosidase		GalNAc-6-O sulfate
MPS IVA	Gal-6-O sulfate and GalNAc-6-O sulfate	hexosaminidase		GalNAc-6-O sulfate
MPS IVA	Gal-6-O sulfate and GalNAc-6-O sulfate	6-O sulfatase	galactosidase	Gal
MPS IVA	Gal-6-O sulfate and GalNAc-6-O sulfate	6-O sulfatase	N-acetyl galactosidase	GalNAc
MPS IVB	Gal	Galactosidase		Gal
MPS VI	GalNAc-4-O sulfate	4-O sulfatase		Sulfate
MPS VI	GalNAc-4-O sulfate	4-O sulfatase	hexosaminidase	GalNAc
MPS VI	GalNAc-4-O sulfate	4-O sulfatase	Chondroitin lyase	GalNAc
MPS VI	GalNAc-4-O sulfate	Chondroitin lyase		GalNAc-4-O sulfate
MPS VII	GlcA	β-glucuronidase		GlcA
Alpha Mannosidosis	Mannose	Manosidase		Man
Aspartylglucosaminuria	GlcNAc	hexosaminidase		GlcNAc
Fabry	Galactose	galactosidase		Gal
Fucosidosis	Fucose	fucosidase		Fuc
Galactosialidosis	Galactose and/or Sialic acid	Galactosidase and/or sialidase		Gal and/or Sialic acid
Gaucher	glucose	glucosidase		glucose
GM1 gangliosidosis	Beta-Galactose	Beta-Galactosidase		galactose
GM1 gangliosidosis	Beta-Galactose	Beta-Galactosidase	Hexosaminidase	GalNAc
GM2 activator deficiency	GalNAc	hexosaminidase		GalNAc
Sialidosis	Sialic acid	Sialidase		Sialic acid
Sialidosis	Sialic acid	Alpha 2,3 Sialidase		Sialic acid
Sialidosis	Sialic acid	Alphas 2,6 Sialidase		Sialic acid
Sialidosis	Sialic acid	Alphas 2,8 Sialidase		Sialic acid
Krabbe	Galactose	galactosidase		Galactose
Metachromatic	Sulfated	3-O sulfatase		Sulfate

TABLE 1-continued

Exemplary LSD Uses

Disease	Non-Reducing End Structure	Primary Releasing Enzyme	Secondary Releasing Enzyme	Glycan Residual Compound
Leukodystrophy Metachromatic Leukodystrophy	galactosylceramide Sulfated galactosylceramide	3-O sulfatase	galactosidase	Galactose
Mucolipidosis II	Broad range of glycans	Any listed enzyme		Any monosaccharide or sulfate
Mucolipidosis III	Broad range of glycans	Any listed enzyme		Any monosaccharide or sulfate
Mucolipidosis IV	Broad range of glycans	Any listed enzyme		Any monosaccharide or sulfate
Multiple Sulfatase Deficiency	Sulfated glycans	sulfatase		sulfate
Multiple Sulfatase Deficiency	Sulfated glycans	sulfatase	Any glycosidase	monosaccharide
Multiple Sulfatase Deficiency	Sulfated glycans	Any glycosidase		Sulfated monosaccharide
Glycogen Storage Disease (Pompe)	glucose	glucosidase		glucose
Sandhoff	GalNAc	hexosaminidase		GalNAc
Tay-Sachs	GalNAc	hexosaminidase		GalNAc
AB Variant	GalNAc	hexosaminidase		GalNAc
Schindler Disease	Alpha-GalNAc	hexosaminidase		GalNAc
Salla Disease	Sialic acid	none		Sialic Acid
Alpha Mannosidosis	Alpha mannose	mannosidase		Mannose
Beta Mannosidosis	Beta mannose	mannosidase		Mannose
Globoid cell leukodystrophy	galactose	galactosidase		galactose

Provided herein are methods of diagnosing individuals (including, e.g., a disease state or the severity of a disease states) with a cancerous disease state or methods of monitoring the treatment of a cancer. Provided in Table 2 are specific embodiments of disease that are optionally diagnosed and/or monitored according to various embodiments described herein. Table 2 also illustrates various non-limiting embodiments of specific enzyme(s) that are optionally utilized to treat a biological sample from an individual suffering from or suspected of (e.g., through a pre- or preliminary screening process) suffering from a cancerous disease state. Moreover, Table 2 further illustrates various glycan residual compounds that are liberated in various embodiments described herein, such liberated glycan residual compounds optionally being detected and/or measured in order to diagnose and/or monitor a cancerous disease state.

TABLE 2

Exemplary Oncology Uses

Cancer Type	Non-Reducing End Structure	Primary Liberating Enzyme	Secondary Liberating Enzyme	Glycan Residual Compound
Melanoma	Sialic Acid	Sialidase		Sialic acid
Melanoma	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Melanoma	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Melanoma	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Melanoma	GalNAc	Hexosaminidase		GalNAc
Melanoma	GalNAc	Sialidase	Hexosaminidase	GalNAc
Melanoma	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Melanoma	Galactose	galactosidase		Galactose
Melanoma	Galactose	sialidase	galactosidase	Galactose
Melanoma	Fucose	fucosidase		Fucose
Melanoma	Galactose	Galactosidase		Galactose
Melanoma	GlcNAc	hexosaminidase		GlcNAc
Melanoma	Sulfate	Sulfatase		Sulfate
Melanoma	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Melanoma	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Neuroblastoma	Sialic Acid	Sialidase		Sialic acid
Neuroblastoma	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Neuroblastoma	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Neuroblastoma	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Neuroblastoma	GalNAc	Hexosaminidase		GalNAc

TABLE 2-continued

Exemplary Oncology Uses				
Cancer Type	Non-Reducing End Structure	Primary Liberating Enzyme	Secondary Liberating Enzyme	Glycan Residual Compound
Neuroblastoma	GalNAc	Sialidase	Hexosaminidase	GalNAc
Neuroblastoma	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Neuroblastoma	Galactose	galactosidase		Galactose
Neuroblastoma	Galactose	sialidase	galactosidase	Galactose
Neuroblastoma	Fucose	fucosidase		Fucose
Neuroblastoma	Galactose	Galactosidase		Galactose
Neuroblastoma	GlcNAc	hexosaminidase		GlcNAc
Neuroblastoma	Sulfate	Sulfatase		Sulfate
Neuroblastoma	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Neuroblastoma	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Adenocarcinoma	Sialic Acid	Sialidase		Sialic acid
Adenocarcinoma	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Adenocarcinoma	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Adenocarcinoma	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Adenocarcinoma	GalNAc	Hexosaminidase		GalNAc
Adenocarcinoma	GalNAc	Sialidase	Hexosaminidase	GalNAc
Adenocarcinoma	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Adenocarcinoma	Galactose	galactosidase		Galactose
Adenocarcinoma	Galactose	sialidase	galactosidase	Galactose
Adenocarcinoma	Fucose	fucosidase		Fucose
Adenocarcinoma	Galactose	Galactosidase		Galactose
Adenocarcinoma	GlcNAc	hexosaminidase		GlcNAc
Adenocarcinoma	Sulfate	Sulfatase		Sulfate
Adenocarcinoma	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Adenocarcinoma	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Myeloma	Sialic Acid	Sialidase		Sialic acid
Myeloma	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Myeloma	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Myeloma	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Myeloma	GalNAc	Hexosaminidase		GalNAc
Myeloma	GalNAc	Sialidase	Hexosaminidase	GalNAc
Myeloma	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Myeloma	Galactose	galactosidase		Galactose
Myeloma	Galactose	sialidase	galactosidase	Galactose
Myeloma	Fucose	fucosidase		Fucose
Myeloma	Galactose	Galactosidase		Galactose
Myeloma	GlcNAc	hexosaminidase		GlcNAc
Myeloma	Sulfate	Sulfatase		Sulfate
Myeloma	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Myeloma	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Breast	Sialic Acid	Sialidase		Sialic acid
Breast	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Breast	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Breast	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Breast	GalNAc	Hexosaminidase		GalNAc
Breast	GalNAc	Sialidase	Hexosaminidase	GalNAc
Breast	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Breast	Galactose	galactosidase		Galactose
Breast	Galactose	sialidase	galactosidase	Galactose
Breast	Fucose	fucosidase		Fucose
Breast	Galactose	Galactosidase		Galactose
Breast	GlcNAc	hexosaminidase		GlcNAc
Breast	Sulfate	Sulfatase		Sulfate
Breast	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Breast	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Ovarian	Sialic Acid	Sialidase		Sialic acid
Ovarian	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Ovarian	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Ovarian	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Ovarian	GalNAc	Hexosaminidase		GalNAc
Ovarian	GalNAc	Sialidase	Hexosaminidase	GalNAc
Ovarian	Sialic acid	Hexosaminidase	Sialidase	Sialic acid

TABLE 2-continued

Exemplary Oncology Uses				
Cancer Type	Non-Reducing End Structure	Primary Liberating Enzyme	Secondary Liberating Enzyme	Glycan Residual Compound
Ovarian	Galactose	galactosidase		Galactose
Ovarian	Galactose	sialidase	galactosidase	Galactose
Ovarian	Fucose	fucosidase		Fucose
Ovarian	Galactose	Galactosidase		Galactose
Ovarian	GlcNAc	hexosaminidase		GlcNAc
Ovarian	Sulfate	Sulfatase		Sulfate
Ovarian	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Ovarian	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Stomach	Sialic Acid	Sialidase		Sialic acid
Stomach	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Stomach	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Stomach	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Stomach	GalNAc	Hexosaminidase		GalNAc
Stomach	GalNAc	Sialidase	Hexosaminidase	GalNAc
Stomach	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Stomach	Galactose	galactosidase		Galactose
Stomach	Galactose	sialidase	galactosidase	Galactose
Stomach	Fucose	fucosidase		Fucose
Stomach	Galactose	Galactosidase		Galactose
Stomach	GlcNAc	hexosaminidase		GlcNAc
Stomach	Sulfate	Sulfatase		Sulfate
Stomach	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Stomach	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Lung	Sialic Acid	Sialidase		Sialic acid
Lung	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Lung	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Lung	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Lung	GalNAc	Hexosaminidase		GalNAc
Lung	GalNAc	Sialidase	Hexosaminidase	GalNAc
Lung	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Lung	Galactose	galactosidase		Galactose
Lung	Galactose	sialidase	galactosidase	Galactose
Lung	Fucose	fucosidase		Fucose
Lung	Galactose	Galactosidase		Galactose
Lung	GlcNAc	hexosaminidase		GlcNAc
Lung	Sulfate	Sulfatase		Sulfate
Lung	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Lung	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Pancreatic	Sialic Acid	Sialidase		Sialic acid
Pancreatic	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Pancreatic	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Pancreatic	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Pancreatic	GalNAc	Hexosaminidase		GalNAc
Pancreatic	GalNAc	Sialidase	Hexosaminidase	GalNAc
Pancreatic	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Pancreatic	Galactose	galactosidase		Galactose
Pancreatic	Galactose	sialidase	galactosidase	Galactose
Pancreatic	Fucose	fucosidase		Fucose
Pancreatic	Galactose	Galactosidase		Galactose
Pancreatic	GlcNAc	hexosaminidase		GlcNAc
Pancreatic	Sulfate	Sulfatase		Sulfate
Pancreatic	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Pancreatic	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Oral	Sialic Acid	Sialidase		Sialic acid
Oral	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Oral	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Oral	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Oral	GalNAc	Hexosaminidase		GalNAc
Oral	GalNAc	Sialidase	Hexosaminidase	GalNAc
Oral	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Oral	Galactose	galactosidase		Galactose
Oral	Galactose	sialidase	galactosidase	Galactose

TABLE 2-continued

Exemplary Oncology Uses				
Cancer Type	Non-Reducing End Structure	Primary Liberating Enzyme	Secondary Liberating Enzyme	Glycan Residual Compound
Oral	Fucose	fucosidase		Fucose
Oral	Galactose	Galactosidase		Galactose
Oral	GlcNAc	hexosaminidase		GlcNAc
Oral	Sulfate	Sulfatase		Sulfate
Oral	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Oral	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Colorectal	Sialic Acid	Sialidase		Sialic acid
Colorectal	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Colorectal	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Colorectal	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Colorectal	GalNAc	Hexosaminidase		GalNAc
Colorectal	GalNAc	Sialidase	Hexosaminidase	GalNAc
Colorectal	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Colorectal	Galactose	galactosidase		Galactose
Colorectal	Galactose	sialidase	galactosidase	Galactose
Colorectal	Fucose	fucosidase		Fucose
Colorectal	Galactose	Galactosidase		Galactose
Colorectal	GlcNAc	hexosaminidase		GlcNAc
Colorectal	Sulfate	Sulfatase		Sulfate
Colorectal	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Colorectal	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Kidney	Sialic Acid	Sialidase		Sialic acid
Kidney	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Kidney	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Kidney	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Kidney	GalNAc	Hexosaminidase		GalNAc
Kidney	GalNAc	Sialidase	Hexosaminidase	GalNAc
Kidney	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Kidney	Galactose	galactosidase		Galactose
Kidney	Galactose	sialidase	galactosidase	Galactose
Kidney	Fucose	fucosidase		Fucose
Kidney	Galactose	Galactosidase		Galactose
Kidney	GlcNAc	hexosaminidase		GlcNAc
Kidney	Sulfate	Sulfatase		Sulfate
Kidney	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Kidney	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Bladder	Sialic Acid	Sialidase		Sialic acid
Bladder	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Bladder	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Bladder	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Bladder	GalNAc	Hexosaminidase		GalNAc
Bladder	GalNAc	Sialidase	Hexosaminidase	GalNAc
Bladder	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Bladder	Galactose	galactosidase		Galactose
Bladder	Galactose	sialidase	galactosidase	Galactose
Bladder	Fucose	fucosidase		Fucose
Bladder	Galactose	Galactosidase		Galactose
Bladder	GlcNAc	hexosaminidase		GlcNAc
Bladder	Sulfate	Sulfatase		Sulfate
Bladder	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Bladder	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Prostate	Sialic Acid	Sialidase		Sialic acid
Prostate	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Prostate	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Prostate	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Prostate	GalNAc	Hexosaminidase		GalNAc
Prostate	GalNAc	Sialidase	Hexosaminidase	GalNAc
Prostate	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Prostate	Galactose	galactosidase		Galactose
Prostate	Galactose	sialidase	galactosidase	Galactose
Prostate	Fucose	fucosidase		Fucose
Prostate	Galactose	Galactosidase		Galactose

TABLE 2-continued

Exemplary Oncology Uses

Cancer Type	Non-Reducing End Structure	Primary Liberating Enzyme	Secondary Liberating Enzyme	Glycan Residual Compound
Prostate	GlcNAc	hexosaminidase		GlcNAc
Prostate	Sulfate	Sulfatase		Sulfate
Prostate	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Prostate	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Uterine	Sialic Acid	Sialidase		Sialic acid
Uterine	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Uterine	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Uterine	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Uterine	GalNAc	Hexosaminidase		GalNAc
Uterine	GalNAc	Sialidase	Hexosaminidase	GalNAc
Uterine	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Uterine	Galactose	galactosidase		Galactose
Uterine	Galactose	sialidase	galactosidase	Galactose
Uterine	Fucose	fucosidase		Fucose
Uterine	Galactose	Galactosidase		Galactose
Uterine	GlcNAc	hexosaminidase		GlcNAc
Uterine	Sulfate	Sulfatase		Sulfate
Uterine	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Uterine	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Thyroid	Sialic Acid	Sialidase		Sialic acid
Thyroid	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Thyroid	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Thyroid	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Thyroid	GalNAc	Hexosaminidase		GalNAc
Thyroid	GalNAc	Sialidase	Hexosaminidase	GalNAc
Thyroid	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Thyroid	Galactose	galactosidase		Galactose
Thyroid	Galactose	sialidase	galactosidase	Galactose
Thyroid	Fucose	fucosidase		Fucose
Thyroid	Galactose	Galactosidase		Galactose
Thyroid	GlcNAc	hexosaminidase		GlcNAc
Thyroid	Sulfate	Sulfatase		Sulfate
Thyroid	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Thyroid	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Liver	Sialic Acid	Sialidase		Sialic acid
Liver	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Liver	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Liver	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Liver	GalNAc	Hexosaminidase		GalNAc
Liver	GalNAc	Sialidase	Hexosaminidase	GalNAc
Liver	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Liver	Galactose	galactosidase		Galactose
Liver	Galactose	sialidase	galactosidase	Galactose
Liver	Fucose	fucosidase		Fucose
Liver	Galactose	Galactosidase		Galactose
Liver	GlcNAc	hexosaminidase		GlcNAc
Liver	Sulfate	Sulfatase		Sulfate
Liver	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Liver	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Esophagus	Sialic Acid	Sialidase		Sialic acid
Esophagus	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Esophagus	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Esophagus	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Esophagus	GalNAc	Hexosaminidase		GalNAc
Esophagus	GalNAc	Sialidase	Hexosaminidase	GalNAc
Esophagus	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Esophagus	Galactose	galactosidase		Galactose
Esophagus	Galactose	sialidase	galactosidase	Galactose
Esophagus	Fucose	fucosidase		Fucose
Esophagus	Galactose	Galactosidase		Galactose
Esophagus	GlcNAc	hexosaminidase		GlcNAc
Esophagus	Sulfate	Sulfatase		Sulfate

TABLE 2-continued

Exemplary Oncology Uses				
Cancer Type	Non-Reducing End Structure	Primary Liberating Enzyme	Secondary Liberating Enzyme	Glycan Residual Compound
Esophagus	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Esophagus	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Brain	Sialic Acid	Sialidase		Sialic acid
Brain	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Brain	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Brain	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Brain	GalNAc	Hexosaminidase		GalNAc
Brain	GalNAc	Sialidase	Hexosaminidase	GalNAc
Brain	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Brain	Galactose	galactosidase		Galactose
Brain	Galactose	sialidase	galactosidase	Galactose
Brain	Fucose	fucosidase		Fucose
Brain	Galactose	Galactosidase		Galactose
Brain	GlcNAc	hexosaminidase		GlcNAc
Brain	Sulfate	Sulfatase		Sulfate
Brain	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Brain	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Lymphomas	Sialic Acid	Sialidase		Sialic acid
Lymphomas	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Lymphomas	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Lymphomas	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Lymphomas	GalNAc	Hexosaminidase		GalNAc
Lymphomas	GalNAc	Sialidase	Hexosaminidase	GalNAc
Lymphomas	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Lymphomas	Galactose	galactosidase		Galactose
Lymphomas	Galactose	sialidase	galactosidase	Galactose
Lymphomas	Fucose	fucosidase		Fucose
Lymphomas	Galactose	Galactosidase		Galactose
Lymphomas	GlcNAc	hexosaminidase		GlcNAc
Lymphomas	Sulfate	Sulfatase		Sulfate
Lymphomas	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Lymphomas	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Leukemias	Sialic Acid	Sialidase		Sialic acid
Leukemias	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Leukemias	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Leukemias	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Leukemias	GalNAc	Hexosaminidase		GalNAc
Leukemias	GalNAc	Sialidase	Hexosaminidase	GalNAc
Leukemias	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Leukemias	Galactose	galactosidase		Galactose
Leukemias	Galactose	sialidase	galactosidase	Galactose
Leukemias	Fucose	fucosidase		Fucose
Leukemias	Galactose	Galactosidase		Galactose
Leukemias	GlcNAc	hexosaminidase		GlcNAc
Leukemias	Sulfate	Sulfatase		Sulfate
Leukemias	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Leukemias	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA

Provided herein are methods of diagnosing individuals (including, e.g., a disease state or the severity of a disease states) with a disease state associated with abnormal glycan accumulation. Provided in Table 3 are specific embodiments of disease that are optionally diagnosed and/or monitored according to various embodiments described herein. Table 3 also illustrates various non-limiting embodiments of specific enzyme(s) that are optionally utilized to treat a biological sample from an individual suffering from or suspected of (e.g., through a pre- or preliminary screening process) suffering from various disease states associated with abnormal glycan accumulation. Moreover, Table 3 further illustrates various glycan residual compounds that are liberated in various embodiments described herein, such liberated glycan residual compounds optionally being detected and/or measured in order to diagnose and/or monitor various disease states.

TABLE 3

Disease	Non-Reducing End Structure	Primary Liberating Enzyme	Secondary Liberating Enzyme	Glycan Residual Compound
Alzheimers	Sialic Acid	Sialidase		Sialic acid
Alzheimers	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Alzheimers	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Alzheimers	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Alzheimers	GalNAc	Hexosaminidase		GalNAc
Alzheimers	GalNAc	Sialidase	Hexosaminidase	GalNAc
Alzheimers	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Alzheimers	Galactose	galactosidase		Galactose
Alzheimers	Galactose	sialidase	galactosidase	Galactose
Alzheimers	Fucose	fucosidase		Fucose
Alzheimers	Galactose	Galactosidase		Galactose
Alzheimers	GlcNAc	hexosaminidase		GlcNAc
Alzheimers	Sulfate	Sulfatase		Sulfate
Alzheimers	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Alzheimers	Sulfated uronic acid	Sulfatase	Iduronidase or glucuronidase	IdoA or GlcA
Amyotrophic Lateral Sclerosis	Sialic Acid	Sialidase		Sialic acid
Amyotrophic Lateral Sclerosis	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Amyotrophic Lateral Sclerosis	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Amyotrophic Lateral Sclerosis	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Amyotrophic Lateral Sclerosis	GalNAc	Hexosaminidase		GalNAc
Amyotrophic Lateral Sclerosis	GalNAc	Sialidase	Hexosaminidase	GalNAc
Amyotrophic Lateral Sclerosis	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Amyotrophic Lateral Sclerosis	Galactose	galactosidase		Galactose
Amyotrophic Lateral Sclerosis	Galactose	sialidase	galactosidase	Galactose
Amyotrophic Lateral Sclerosis	Fucose	fucosidase		Fucose
Amyotrophic Lateral Sclerosis	Galactose	Galactosidase		Galactose
Amyotrophic Lateral Sclerosis	GlcNAc	hexosaminidase		GlcNAc
Amyotrophic Lateral Sclerosis	Sulfate	Sulfatase		Sulfate
Amyotrophic Lateral Sclerosis	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Amyotrophic Lateral Sclerosis	Sulfated uronic acid	Sulfatase	Iduronidase or glucuronidase	IdoA or GlcA
Cerebral Palsy	Sialic Acid	Sialidase		Sialic acid
Cerebral Palsy	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Cerebral Palsy	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Cerebral Palsy	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Cerebral Palsy	GalNAc	Hexosaminidase		GalNAc
Cerebral Palsy	GalNAc	Sialidase	Hexosaminidase	GalNAc
Cerebral Palsy	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Cerebral Palsy	Galactose	galactosidase		Galactose
Cerebral Palsy	Galactose	sialidase	galactosidase	Galactose
Cerebral Palsy	Fucose	fucosidase		Fucose
Cerebral Palsy	Galactose	Galactosidase		Galactose
Cerebral Palsy	GlcNAc	hexosaminidase		GlcNAc
Cerebral Palsy	Sulfate	Sulfatase		Sulfate
Cerebral Palsy	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Cerebral Palsy	Sulfated uronic acid	Sulfatase	Iduronidase or glucuronidase	IdoA or GlcA
Schizophrenia	Sialic Acid	Sialidase		Sialic acid
Schizophrenia	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Schizophrenia	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid

TABLE 3-continued

Disease	Non-Reducing End Structure	Primary Liberating Enzyme	Secondary Liberating Enzyme	Glycan Residual Compound
Schizophrenia	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Schizophrenia	GalNAc	Hexosaminidase		GalNAc
Schizophrenia	GalNAc	Sialidase	Hexosaminidase	GalNAc
Schizophrenia	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Schizophrenia	Galactose	galactosidase		Galactose
Schizophrenia	Galactose	sialidase	galactosidase	Galactose
Schizophrenia	Fucose	fucosidase		Fucose
Schizophrenia	Galactose	Galactosidase		Galactose
Schizophrenia	GlcNAc	hexosaminidase		GlcNAc
Schizophrenia	Sulfate	Sulfatase		Sulfate
Schizophrenia	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Schizophrenia	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Bipolar Disorder	Sialic Acid	Sialidase		Sialic acid
Bipolar Disorder	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Bipolar Disorder	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Bipolar Disorder	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Bipolar Disorder	GalNAc	Hexosaminidase		GalNAc
Bipolar Disorder	GalNAc	Sialidase	Hexosaminidase	GalNAc
Bipolar Disorder	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Bipolar Disorder	Galactose	galactosidase		Galactose
Bipolar Disorder	Galactose	sialidase	galactosidase	Galactose
Bipolar Disorder	Fucose	fucosidase		Fucose
Bipolar Disorder	Galactose	Galactosidase		Galactose
Bipolar Disorder	GlcNAc	hexosaminidase		GlcNAc
Bipolar Disorder	Sulfate	Sulfatase		Sulfate
Bipolar Disorder	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Bipolar Disorder	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Depression	Sialic Acid	Sialidase		Sialic acid
Depression	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Depression	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Depression	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Depression	GalNAc	Hexosaminidase		GalNAc
Depression	GalNAc	Sialidase	Hexosaminidase	GalNAc
Depression	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Depression	Galactose	galactosidase		Galactose
Depression	Galactose	sialidase	galactosidase	Galactose
Depression	Fucose	fucosidase		Fucose
Depression	Galactose	Galactosidase		Galactose
Depression	GlcNAc	hexosaminidase		GlcNAc
Depression	Sulfate	Sulfatase		Sulfate
Depression	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Depression	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Epilepsy	Sialic Acid	Sialidase		Sialic acid
Epilepsy	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Epilepsy	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Epilepsy	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Epilepsy	GalNAc	Hexosaminidase		GalNAc
Epilepsy	GalNAc	Sialidase	Hexosaminidase	GalNAc
Epilepsy	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Epilepsy	Galactose	galactosidase		Galactose
Epilepsy	Galactose	sialidase	galactosidase	Galactose
Epilepsy	Fucose	fucosidase		Fucose
Epilepsy	Galactose	Galactosidase		Galactose
Epilepsy	GlcNAc	hexosaminidase		GlcNAc
Epilepsy	Sulfate	Sulfatase		Sulfate
Epilepsy	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Epilepsy	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA

TABLE 3-continued

Disease	Non-Reducing End Structure	Primary Liberating Enzyme	Secondary Liberating Enzyme	Glycan Residual Compound
Migraine	Sialic Acid	Sialidase		Sialic acid
Migraine	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Migraine	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Migraine	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Migraine	GalNAc	Hexosaminidase		GalNAc
Migraine	GalNAc	Sialidase	Hexosaminidase	GalNAc
Migraine	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Migraine	Galactose	galactosidase		Galactose
Migraine	Galactose	sialidase	galactosidase	Galactose
Migraine	Fucose	fucosidase		Fucose
Migraine	Galactose	Galactosidase		Galactose
Migraine	GlcNAc	hexosaminidase		GlcNAc
Migraine	Sulfate	Sulfatase		Sulfate
Migraine	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Migraine	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Multiple Sclerosis	Sialic Acid	Sialidase		Sialic acid
Multiple Sclerosis	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Multiple Sclerosis	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Multiple Sclerosis	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Multiple Sclerosis	GalNAc	Hexosaminidase		GalNAc
Multiple Sclerosis	GalNAc	Sialidase	Hexosaminidase	GalNAc
Multiple Sclerosis	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Multiple Sclerosis	Galactose	galactosidase		Galactose
Multiple Sclerosis	Galactose	sialidase	galactosidase	Galactose
Multiple Sclerosis	Fucose	fucosidase		Fucose
Multiple Sclerosis	Galactose	Galactosidase		Galactose
Multiple Sclerosis	GlcNAc	hexosaminidase		GlcNAc
Multiple Sclerosis	Sulfate	Sulfatase		Sulfate
Multiple Sclerosis	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Multiple Sclerosis	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Parkinson's	Sialic Acid	Sialidase		Sialic acid
Parkinson's	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Parkinson's	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Parkinson's	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Parkinson's	GalNAc	Hexosaminidase		GalNAc
Parkinson's	GalNAc	Sialidase	Hexosaminidase	GalNAc
Parkinson's	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Parkinson's	Galactose	galactosidase		Galactose
Parkinson's	Galactose	sialidase	galactosidase	Galactose
Parkinson's	Fucose	fucosidase		Fucose
Parkinson's	Galactose	Galactosidase		Galactose
Parkinson's	GlcNAc	hexosaminidase		GlcNAc
Parkinson's	Sulfate	Sulfatase		Sulfate
Parkinson's	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Parkinson's	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Rheumatoid Arthritis	Sialic Acid	Sialidase		Sialic acid
Rheumatoid Arthritis	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Rheumatoid Arthritis	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Rheumatoid Arthritis	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Rheumatoid Arthritis	GalNAc	Hexosaminidase		GalNAc
Rheumatoid Arthritis	GalNAc	Sialidase	Hexosaminidase	GalNAc
Rheumatoid Arthritis	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Rheumatoid Arthritis	Galactose	galactosidase		Galactose
Rheumatoid Arthritis	Galactose	sialidase	galactosidase	Galactose
Rheumatoid Arthritis	Fucose	fucosidase		Fucose
Rheumatoid Arthritis	Galactose	Galactosidase		Galactose
Rheumatoid Arthritis	GlcNAc	hexosaminidase		GlcNAc
Rheumatoid Arthritis	Sulfate	Sulfatase		Sulfate

TABLE 3-continued

Disease	Non-Reducing End Structure	Primary Liberating Enzyme	Secondary Liberating Enzyme	Glycan Residual Compound
Rheumatoid Arthritis	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Rheumatoid Arthritis	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Psoriatic Arthritis	Sialic Acid	Sialidase		Sialic acid
Psoriatic Arthritis	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Psoriatic Arthritis	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Psoriatic Arthritis	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Psoriatic Arthritis	GalNAc	Hexosaminidase		GalNAc
Psoriatic Arthritis	GalNAc	Sialidase	Hexosaminidase	GalNAc
Psoriatic Arthritis	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Psoriatic Arthritis	Galactose	galactosidase		Galactose
Psoriatic Arthritis	Galactose	sialidase	galactosidase	Galactose
Psoriatic Arthritis	Fucose	fucosidase		Fucose
Psoriatic Arthritis	Galactose	Galactosidase		Galactose
Psoriatic Arthritis	GlcNAc	hexosaminidase		GlcNAc
Psoriatic Arthritis	Sulfate	Sulfatase		Sulfate
Psoriatic Arthritis	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Psoriatic Arthritis	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Asthma	Sialic Acid	Sialidase		Sialic acid
Asthma	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Asthma	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Asthma	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Asthma	GalNAc	Hexosaminidase		GalNAc
Asthma	GalNAc	Sialidase	Hexosaminidase	GalNAc
Asthma	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Asthma	Galactose	galactosidase		Galactose
Asthma	Galactose	sialidase	galactosidase	Galactose
Asthma	Fucose	fucosidase		Fucose
Asthma	Galactose	Galactosidase		Galactose
Asthma	GlcNAc	hexosaminidase		GlcNAc
Asthma	Sulfate	Sulfatase		Sulfate
Asthma	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Asthma	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Chronic Obstructive Pulmonary Disorder	Sialic Acid	Sialidase		Sialic acid
Chronic Obstructive Pulmonary Disorder	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Chronic Obstructive Pulmonary Disorder	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Chronic Obstructive Pulmonary Disorder	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Chronic Obstructive Pulmonary Disorder	GalNAc	Hexosaminidase		GalNAc
Chronic Obstructive Pulmonary Disorder	GalNAc	Sialidase	Hexosaminidase	GalNAc
Chronic Obstructive Pulmonary Disorder	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Chronic Obstructive Pulmonary Disorder	Galactose	galactosidase		Galactose
Chronic Obstructive Pulmonary Disorder	Galactose	sialidase	galactosidase	Galactose
Chronic Obstructive Pulmonary Disorder	Fucose	fucosidase		Fucose
Chronic Obstructive Pulmonary Disorder	Galactose	Galactosidase		Galactose
Chronic Obstructive Pulmonary Disorder	GlcNAc	hexosaminidase		GlcNAc
Chronic Obstructive Pulmonary Disorder	Sulfate	Sulfatase		Sulfate
Chronic Obstructive Pulmonary Disorder	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Chronic Obstructive Pulmonary Disorder	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Lupus	Sialic Acid	Sialidase		Sialic acid

TABLE 3-continued

Disease	Non-Reducing End Structure	Primary Liberating Enzyme	Secondary Liberating Enzyme	Glycan Residual Compound
Lupus	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Lupus	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Lupus	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Lupus	GalNAc	Hexosaminidase		GalNAc
Lupus	GalNAc	Sialidase	Hexosaminidase	GalNAc
Lupus	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Lupus	Galactose	galactosidase		Galactose
Lupus	Galactose	sialidase	galactosidase	Galactose
Lupus	Fucose	fucosidase		Fucose
Lupus	Galactose	Galactosidase		Galactose
Lupus	GlcNAc	hexosaminidase		GlcNAc
Lupus	Sulfate	Sulfatase		Sulfate
Lupus	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Lupus	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Hepatitis	Sialic Acid	Sialidase		Sialic acid
Hepatitis	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Hepatitis	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Hepatitis	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Hepatitis	GalNAc	Hexosaminidase		GalNAc
Hepatitis	GalNAc	Sialidase	Hexosaminidase	GalNAc
Hepatitis	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Hepatitis	Galactose	galactosidase		Galactose
Hepatitis	Galactose	sialidase	galactosidase	Galactose
Hepatitis	Fucose	fucosidase		Fucose
Hepatitis	Galactose	Galactosidase		Galactose
Hepatitis	GlcNAc	hexosaminidase		GlcNAc
Hepatitis	Sulfate	Sulfatase		Sulfate
Hepatitis	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Hepatitis	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Renal Disease	Sialic Acid	Sialidase		Sialic acid
Renal Disease	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Renal Disease	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Renal Disease	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Renal Disease	GalNAc	Hexosaminidase		GalNAc
Renal Disease	GalNAc	Sialidase	Hexosaminidase	GalNAc
Renal Disease	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Renal Disease	Galactose	galactosidase		Galactose
Renal Disease	Galactose	sialidase	galactosidase	Galactose
Renal Disease	Fucose	fucosidase		Fucose
Renal Disease	Galactose	Galactosidase		Galactose
Renal Disease	GlcNAc	hexosaminidase		GlcNAc
Renal Disease	Sulfate	Sulfatase		Sulfate
Renal Disease	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Renal Disease	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Sickle Cell Disease	Sialic Acid	Sialidase		Sialic acid
Sickle Cell Disease	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Sickle Cell Disease	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Sickle Cell Disease	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Sickle Cell Disease	GalNAc	Hexosaminidase		GalNAc
Sickle Cell Disease	GalNAc	Sialidase	Hexosaminidase	GalNAc
Sickle Cell Disease	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Sickle Cell Disease	Galactose	galactosidase		Galactose
Sickle Cell Disease	Galactose	sialidase	galactosidase	Galactose
Sickle Cell Disease	Fucose	fucosidase		Fucose
Sickle Cell Disease	Galactose	Galactosidase		Galactose
Sickle Cell Disease	GlcNAc	hexosaminidase		GlcNAc
Sickle Cell Disease	Sulfate	Sulfatase		Sulfate

TABLE 3-continued

Disease	Non-Reducing End Structure	Primary Liberating Enzyme	Secondary Liberating Enzyme	Glycan Residual Compound
Sickle Cell Disease	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Sickle Cell Disease	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Fibromyalgia	Sialic Acid	Sialidase		Sialic acid
Fibromyalgia	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Fibromyalgia	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Fibromyalgia	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Fibromyalgia	GalNAc	Hexosaminidase		GalNAc
Fibromyalgia	GalNAc	Sialidase	Hexosaminidase	GalNAc
Fibromyalgia	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Fibromyalgia	Galactose	galactosidase		Galactose
Fibromyalgia	Galactose	sialidase	galactosidase	Galactose
Fibromyalgia	Fucose	fucosidase		Fucose
Fibromyalgia	Galactose	Galactosidase		Galactose
Fibromyalgia	GlcNAc	hexosaminidase		GlcNAc
Fibromyalgia	Sulfate	Sulfatase		Sulfate
Fibromyalgia	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Fibromyalgia	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Irritable Bowel Syndrome	Sialic Acid	Sialidase		Sialic acid
Irritable Bowel Syndrome	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Irritable Bowel Syndrome	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Irritable Bowel Syndrome	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Irritable Bowel Syndrome	GalNAc	Hexosaminidase		GalNAc
Irritable Bowel Syndrome	GalNAc	Sialidase	Hexosaminidase	GalNAc
Irritable Bowel Syndrome	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Irritable Bowel Syndrome	Galactose	galactosidase		Galactose
Irritable Bowel Syndrome	Galactose	sialidase	galactosidase	Galactose
Irritable Bowel Syndrome	Fucose	fucosidase		Fucose
Irritable Bowel Syndrome	Galactose	Galactosidase		Galactose
Irritable Bowel Syndrome	GlcNAc	hexosaminidase		GlcNAc
Irritable Bowel Syndrome	Sulfate	Sulfatase		Sulfate
Irritable Bowel Syndrome	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Irritable Bowel Syndrome	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Ulcer	Sialic Acid	Sialidase		Sialic acid
Ulcer	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Ulcer	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Ulcer	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Ulcer	GalNAc	Hexosaminidase		GalNAc
Ulcer	GalNAc	Sialidase	Hexosaminidase	GalNAc
Ulcer	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Ulcer	Galactose	galactosidase		Galactose
Ulcer	Galactose	sialidase	galactosidase	Galactose
Ulcer	Fucose	fucosidase		Fucose
Ulcer	Galactose	Galactosidase		Galactose
Ulcer	GlcNAc	hexosaminidase		GlcNAc
Ulcer	Sulfate	Sulfatase		Sulfate
Ulcer	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Ulcer	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Irritable Bowel Disease	Sialic Acid	Sialidase		Sialic acid

TABLE 3-continued

Disease	Non-Reducing End Structure	Primary Liberating Enzyme	Secondary Liberating Enzyme	Glycan Residual Compound
Irritable Bowel Disease	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Irritable Bowel Disease	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Irritable Bowel Disease	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Irritable Bowel Disease	GalNAc	Hexosaminidase		GalNAc
Irritable Bowel Disease	GalNAc	Sialidase	Hexosaminidase	GalNAc
Irritable Bowel Disease	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Irritable Bowel Disease	Galactose	galactosidase		Galactose
Irritable Bowel Disease	Galactose	sialidase	galactosidase	Galactose
Irritable Bowel Disease	Fucose	fucosidase		Fucose
Irritable Bowel Disease	Galactose	Galactosidase		Galactose
Irritable Bowel Disease	GlcNAc	hexosaminidase		GlcNAc
Irritable Bowel Disease	Sulfate	Sulfatase		Sulfate
Irritable Bowel Disease	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Irritable Bowel Disease	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Coronary Artery Disease	Sialic Acid	Sialidase		Sialic acid
Coronary Artery Disease	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Coronary Artery Disease	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Coronary Artery Disease	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Coronary Artery Disease	GalNAc	Hexosaminidase		GalNAc
Coronary Artery Disease	GalNAc	Sialidase	Hexosaminidase	GalNAc
Coronary Artery Disease	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Coronary Artery Disease	Galactose	galactosidase		Galactose
Coronary Artery Disease	Galactose	sialidase	galactosidase	Galactose
Coronary Artery Disease	Fucose	fucosidase		Fucose
Coronary Artery Disease	Galactose	Galactosidase		Galactose
Coronary Artery Disease	GlcNAc	hexosaminidase		GlcNAc
Coronary Artery Disease	Sulfate	Sulfatase		Sulfate
Coronary Artery Disease	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Coronary Artery Disease	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Restenosis	Sialic Acid	Sialidase		Sialic acid
Restenosis	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Restenosis	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Restenosis	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Restenosis	GalNAc	Hexosaminidase		GalNAc
Restenosis	GalNAc	Sialidase	Hexosaminidase	GalNAc
Restenosis	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Restenosis	Galactose	galactosidase		Galactose
Restenosis	Galactose	sialidase	galactosidase	Galactose
Restenosis	Fucose	fucosidase		Fucose
Restenosis	Galactose	Galactosidase		Galactose
Restenosis	GlcNAc	hexosaminidase		GlcNAc
Restenosis	Sulfate	Sulfatase		Sulfate
Restenosis	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Restenosis	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Stroke	Sialic Acid	Sialidase		Sialic acid
Stroke	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Stroke	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Stroke	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Stroke	GalNAc	Hexosaminidase		GalNAc
Stroke	GalNAc	Sialidase	Hexosaminidase	GalNAc
Stroke	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Stroke	Galactose	galactosidase		Galactose
Stroke	Galactose	sialidase	galactosidase	Galactose
Stroke	Fucose	fucosidase		Fucose
Stroke	Galactose	Galactosidase		Galactose
Stroke	GlcNAc	hexosaminidase		GlcNAc
Stroke	Sulfate	Sulfatase		Sulfate

TABLE 3-continued

Disease	Non-Reducing End Structure	Primary Liberating Enzyme	Secondary Liberating Enzyme	Glycan Residual Compound
Stroke	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Stroke	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Diabetes	Sialic Acid	Sialidase		Sialic acid
Diabetes	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Diabetes	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Diabetes	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Diabetes	GalNAc	Hexosaminidase		GalNAc
Diabetes	GalNAc	Sialidase	Hexosaminidase	GalNAc
Diabetes	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Diabetes	Galactose	galactosidase		Galactose
Diabetes	Galactose	sialidase	galactosidase	Galactose
Diabetes	Fucose	fucosidase		Fucose
Diabetes	Galactose	Galactosidase		Galactose
Diabetes	GlcNAc	hexosaminidase		GlcNAc
Diabetes	Sulfate	Sulfatase		Sulfate
Diabetes	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Diabetes	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Hyperheparanemia	Sialic Acid	Sialidase		Sialic acid
Hyperheparanemia	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Hyperheparanemia	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Hyperheparanemia	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Hyperheparanemia	GalNAc	Hexosaminidase		GalNAc
Hyperheparanemia	GalNAc	Sialidase	Hexosaminidase	GalNAc
Hyperheparanemia	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Hyperheparanemia	Galactose	galactosidase		Galactose
Hyperheparanemia	Galactose	sialidase	galactosidase	Galactose
Hyperheparanemia	Fucose	fucosidase		Fucose
Hyperheparanemia	Galactose	Galactosidase		Galactose
Hyperheparanemia	GlcNAc	hexosaminidase		GlcNAc
Hyperheparanemia	Sulfate	Sulfatase		Sulfate
Hyperheparanemia	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Hyperheparanemia	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Hypergangliosidemia	Sialic Acid	Sialidase		Sialic acid
Hypergangliosidemia	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Hypergangliosidemia	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Hypergangliosidemia	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Hypergangliosidemia	GalNAc	Hexosaminidase		GalNAc
Hypergangliosidemia	GalNAc	Sialidase	Hexosaminidase	GalNAc
Hypergangliosidemia	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Hypergangliosidemia	Galactose	galactosidase		Galactose
Hypergangliosidemia	Galactose	sialidase	galactosidase	Galactose
Hypergangliosidemia	Fucose	fucosidase		Fucose
Hypergangliosidemia	Galactose	Galactosidase		Galactose
Hypergangliosidemia	GlcNAc	hexosaminidase		GlcNAc
Hypergangliosidemia	Sulfate	Sulfatase		Sulfate
Hypergangliosidemia	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Hypergangliosidemia	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Hypermucinemia	Sialic Acid	Sialidase		Sialic acid
Hypermucinemia	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Hypermucinemia	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Hypermucinemia	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Hypermucinemia	GalNAc	Hexosaminidase		GalNAc
Hypermucinemia	GalNAc	Sialidase	Hexosaminidase	GalNAc
Hypermucinemia	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Hypermucinemia	Galactose	galactosidase		Galactose
Hypermucinemia	Galactose	sialidase	galactosidase	Galactose

TABLE 3-continued

Disease	Non-Reducing End Structure	Primary Liberating Enzyme	Secondary Liberating Enzyme	Glycan Residual Compound
Hypermucinemia	Fucose	fucosidase		Fucose
Hypermucinemia	Galactose	Galactosidase		Galactose
Hypermucinemia	GlcNAc	hexosaminidase		GlcNAc
Hypermucinemia	Sulfate	Sulfatase		Sulfate
Hypermucinemia	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Hypermucinemia	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Hyper O-linked glycanemia	Sialic Acid	Sialidase		Sialic acid
Hyper O-linked glycanemia	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Hyper O-linked glycanemia	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Hyper O-linked glycanemia	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Hyper O-linked glycanemia	GalNAc	Hexosaminidase		GalNAc
Hyper O-linked glycanemia	GalNAc	Sialidase	Hexosaminidase	GalNAc
Hyper O-linked glycanemia	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Hyper O-linked glycanemia	Galactose	galactosidase		Galactose
Hyper O-linked glycanemia	Galactose	sialidase	galactosidase	Galactose
Hyper O-linked glycanemia	Fucose	fucosidase		Fucose
Hyper O-linked glycanemia	Galactose	Galactosidase		Galactose
Hyper O-linked glycanemia	GlcNAc	hexosaminidase		GlcNAc
Hyper O-linked glycanemia	Sulfate	Sulfatase		Sulfate
Hyper O-linked glycanemia	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Hyper O-linked glycanemia	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Hyper N-linked glycanemia	Sialic Acid	Sialidase		Sialic acid
Hyper N-linked glycanemia	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Hyper N-linked glycanemia	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Hyper N-linked glycanemia	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Hyper N-linked glycanemia	GalNAc	Hexosaminidase		GalNAc
Hyper N-linked glycanemia	GalNAc	Sialidase	Hexosaminidase	GalNAc
Hyper N-linked glycanemia	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Hyper N-linked glycanemia	Galactose	galactosidase		Galactose
Hyper N-linked glycanemia	Galactose	sialidase	galactosidase	Galactose
Hyper N-linked glycanemia	Fucose	fucosidase		Fucose
Hyper N-linked glycanemia	Galactose	Galactosidase		Galactose
Hyper N-linked glycanemia	GlcNAc	hexosaminidase		GlcNAc
Hyper N-linked glycanemia	Sulfate	Sulfatase		Sulfate
Hyper N-linked glycanemia	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Hyper N-linked glycanemia	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Hypersialylemia	Sialic Acid	Sialidase		Sialic acid
Hypersialylemia	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Hypersialylemia	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Hypersialylemia	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Hypersialylemia	GalNAc	Hexosaminidase		GalNAc

TABLE 3-continued

Disease	Non-Reducing End Structure	Primary Liberating Enzyme	Secondary Liberating Enzyme	Glycan Residual Compound
Hypersialylemia	GalNAc	Sialidase	Hexosaminidase	GalNAc
Hypersialylemia	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Hypersialylemia	Galactose	galactosidase		Galactose
Hypersialylemia	Galactose	sialidase	galactosidase	Galactose
Hypersialylemia	Fucose	fucosidase		Fucose
Hypersialylemia	Galactose	Galactosidase		Galactose
Hypersialylemia	GlcNAc	hexosaminidase		GlcNAc
Hypersialylemia	Sulfate	Sulfatase		Sulfate
Hypersialylemia	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Hypersialylemia	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Hyperfucosylemia	Sialic Acid	Sialidase		Sialic acid
Hyperfucosylemia	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Hyperfucosylemia	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Hyperfucosylemia	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Hyperfucosylemia	GalNAc	Hexosaminidase		GalNAc
Hyperfucosylemia	GalNAc	Sialidase	Hexosaminidase	GalNAc
Hyperfucosylemia	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Hyperfucosylemia	Galactose	galactosidase		Galactose
Hyperfucosylemia	Galactose	sialidase	galactosidase	Galactose
Hyperfucosylemia	Fucose	fucosidase		Fucose
Hyperfucosylemia	Galactose	Galactosidase		Galactose
Hyperfucosylemia	GlcNAc	hexosaminidase		GlcNAc
Hyperfucosylemia	Sulfate	Sulfatase		Sulfate
Hyperfucosylemia	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Hyperfucosylemia	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA
Hypersulfogycanemia	Sialic Acid	Sialidase		Sialic acid
Hypersulfogycanemia	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Hypersulfogycanemia	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Hypersulfogycanemia	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Hypersulfogycanemia	GalNAc	Hexosaminidase		GalNAc
Hypersulfogycanemia	GalNAc	Sialidase	Hexosaminidase	GalNAc
Hypersulfogycanemia	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Hypersulfogycanemia	Galactose	galactosidase		Galactose
Hypersulfogycanemia	Galactose	sialidase	galactosidase	Galactose
Hypersulfogycanemia	Fucose	fucosidase		Fucose
Hypersulfogycanemia	Galactose	Galactosidase		Galactose
Hypersulfogycanemia	GlcNAc	hexosaminidase		GlcNAc
Hypersulfogycanemia	Sulfate	Sulfatase		Sulfate
Hypersulfogycanemia	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Hypersulfogycanemia	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA

Provided herein are methods of diagnosing individuals (including, e.g., a disease state or the severity of a disease states) with an infectious disease state associated with abnormal glycan accumulation. Provided in Table 4 are specific embodiments of disease that are optionally diagnosed and/or monitored according to various embodiments described herein. Table 4 also illustrates various non-limiting embodiments of specific enzyme(s) that are optionally utilized to treat a biological sample from an individual suffering from or suspected of (e.g., through a pre- or preliminary screening process) suffering from various infectious disease states associated with abnormal glycan accumulation. Moreover, Table 4 further illustrates various glycan residual compounds that are liberated in various embodiments described herein, such liberated glycan residual compounds optionally being detected and/or measured in order to diagnose and/or monitor various infectious disease states.

TABLE 4

Infectious Diseases				
Disease	Non-Reducing end structure	Primary Liberating Enzyme	Secondary Liberating Enzyme	Glycan Residual Compound
Bacterial Infections	Mannose	Mannosidase		Mannose
Bacterial Infections	Fucose	Fucosidase		Fucose
Bacterial Infections	Glucose	Glucosidase		Glucose
Bacterial Infections	Galactose	Galactosidase		Galactose
Bacterial Infections	GlcNAc	hexosaminidase		GlcNAc
Bacterial Infections	GalNAc	hexosaminidase		GalNAc
Bacterial Infections	Arabinose	Arabinosidase		Arabinose
Bacterial Infections	Xylose	Xylosidase		Xylose
Bacterial Infections	Ribose	Ribosidase		Ribose
Bacterial Infections	Lyxose	Lyxosidase		Lyxose
Bacterial Infections	Talose	Talosidase		Talose
Bacterial Infections	Idose	Idosidase		Idose
Bacterial Infections	Gulose	Gulosidase		Gulose
Bacterial Infections	Altrose	Altrosidase		Altrose
Bacterial Infections	Allose	Allosidase		Allose
Fungal Infections	Mannose	Mannosidase		Mannose
Fungal Infections	Fucose	Fucosidase		Fucose
Fungal Infections	Glucose	Glucosidase		Glucose
Fungal Infections	Galactose	Galactosidase		Galactose
Fungal Infections	GlcNAc	hexosaminidase		GlcNAc
Fungal Infections	GalNAc	hexosaminidase		GalNAc
Fungal Infections	Arabinose	Arabinosidase		Arabinose
Fungal Infections	Xylose	Xylosidase		Xylose
Fungal Infections	Ribose	Ribosidase		Ribose
Fungal Infections	Lyxose	Lyxosidase		Lyxose
Fungal Infections	Talose	Talosidase		Talose
Fungal Infections	Idose	Idosidase		Idose
Fungal Infections	Gulose	Gulosidase		Gulose
Fungal Infections	Altrose	Altrosidase		Altrose
Fungal Infections	Allose	Allosidase		Allose
Viral Infections	Sialic Acid	Sialidase		Sialic acid
Viral Infections	Sialic Acid	Alpha 2,8 Sialidase		Sialic acid
Viral Infections	Sialic Acid	Alpha 2,3 Sialidase		Sialic acid
Viral Infections	Sialic Acid	Alpha 2,6 Sialidase		Sialic acid
Viral Infections	GalNAc	Hexosaminidase		GalNAc
Viral Infections	GalNAc	Sialidase	Hexosaminidase	GalNAc
Viral Infections	Sialic acid	Hexosaminidase	Sialidase	Sialic acid
Viral Infections	Galactose	galactosidase		Galactose
Viral Infections	Galactose	sialidase	galactosidase	Galactose
Viral Infections	Fucose	fucosidase		Fucose
Viral Infections	Galactose	Galactosidase		Galactose
Viral Infections	GlcNAc	hexosaminidase		GlcNAc
Viral Infections	Sulfate	Sulfatase		Sulfate
Viral Infections	Sulfated hexose	Sulfatase	hexosaminidase	GlcNAc or GalNAc
Viral Infections	Sulfated uronic acid	Sulfatase	Iduronidase or glucouronidase	IdoA or GlcA

FIG. **1** illustrates compounds present in a normal biological sample not subject to an enzymatic glycan residual liberation process described herein. FIG. **2** illustrates compounds present in a normal biological subject to an enzymatic glycan residual liberation process described herein. FIG. **3** illustrates compounds present in a biological sample of an individual suffering from a disorder associated with abnormal glycan accumulation not subject to an enzymatic glycan residual liberation process described herein. FIG. **4** illustrates compounds present in a biological sample of an individual suffering from a disorder associated with abnormal glycan accumulation subject to an enzymatic glycan residual liberation process described herein.

Detecting and Measuring:

Glycan residual compounds (including, e.g., oligosaccharides, monosaccharides, sulfate, phosphate, sialic acid, acetate, or the like) described herein are detected and/or measured in processes described herein in any suitable manner. In some embodiments, glycan residual compounds are detected and/or measured in unmodified form. In other embodiments, glycan residual compounds are tagged with a detectable label prior and the labeled glycan residual compound is detected.

In some embodiments, non-labeled compounds are optionally detected and/or measured in any suitable manner, e.g., by pH, by quantitative nuclear magnetic resonance (NMR), or the like.

In various embodiments, a method described herein comprises determining whether the amount of liberated glycan residue is abnormal and such a determination comprises labeling the glycan residue with a detectable label and measuring the amount of labeled glycan residue with an analytical instrument. In specific embodiments, the detectable label is a mass label, a radioisotope label, a fluorescent label, a chromophore label, or affinity label. In some embodiments, the

amount of liberated glycan is measured using UV-Vis spectroscopy, IR spectroscopy, mass spectrometry, or a combination thereof.

In the various embodiments of any process or method described herein, any suitable detectable label is optionally utilized. In some embodiments, detectable labels useful in the processes or methods described herein include, by way of non-limiting example, mass labels, antibodies, affinity labels, radioisotope labels, chromophores, fluorescent labels, or the like.

Fluorescent labels suitable for use in various embodiments herein include, by way of non-limiting example, 2-aminopyridine (2-AP), 2-aminobenzoic acid (2-AA), 2-aminobenzamide (2-AB), 2-aminoacridone (AMAC), p-aminobenzoic acid ethyl ester (ABEE), p-aminobenzonitrile (ABN), 2-amino-6-cyanoethylpyridine (ACP), 7-amino-4-methylcoumarine (AMC), 8-aminonaphthalene-1,3,6-trisulfate (ANTS), 7-aminonaphthalene-1,3-disulfide (ANDS), and 8-aminopyrene-1,3,6-trisulfate (APTS), or the like. The fluorescent labels can be attached by reductive amination with the fluorescent label and sodium cyanoborohydride or the like.

Mass labels suitable for use in various embodiments herein include, by way of non-limiting example, D-2-anthranilic acid, D-2-aminopyridine, D-methyl iodide, ^{13}C methyl iodide, deuterated-pyridyl-amine, D-biotin or the like. The mass labels can be attached by permethylation or reductive amination by any method that is known to those of skill in the art.

Affinity labels suitable for use in various embodiments herein include, by way of non-limiting example, biotin and derivatives.

Radioisotope labels suitable for use in various embodiments herein include, by way of non-limiting example, sodium borotritide (NaB^3H_4), ^3H, ^{14}C, ^{32}P, ^{35}S, or the like.

Chromophores suitable for use in various embodiments herein include, by way of non-limiting example, 4-amino-1,1'-azobenzene, 4'-N,N-dimethylamino-4-aminoazobenzene, aminoazobenzene, diaminoazobenzene, Direct Red 16, CI Acid Red 57, CI Acid Blue 45, CI Acid Blue 22, CL Mordant Brown 13, CI Direct Orange 75, or the like. The chromophores may be labeled by any method that is known to those of skill in the art, such as reductive amination with the chromophore and sodium cyanoborohydride.

In some embodiments, the detectable label is an antibody. In specific embodiments, the antibody is attached to a detectable compound, such as mass labels, radioisotope labels, chromophores, fluorescent labels, or the like. In some embodiments, antibodies are themselves detected and/or are detectable in various manners, e.g., as a chromophore, a fluorophore, or the like; or with a probe (e.g., using dot blot techniques, immune-detection techniques, or the like).

In certain embodiments, detectable labels are detected and/or quantified according to any process described herein using any technique, particularly any technique suitable for the detectable label utilized. In some embodiments, suitable detection techniques include, by way of non-limiting example, one or more of a mass spectrometer, a nuclear magnetic resonance spectrometer, a UV-Vis spectrometer, an IR spectrometer, a fluorimeter, a phosphorimeter, a radiation spectrometer (e.g., a scintillation counter), a thin layer chromatographic technique, or the like. In certain embodiments, in any process described herein, glycan residual compounds are optionally directly detected using a suitable technique, such as quantitative nuclear magnetic resonance. Quantitative nuclear magnetic resonance is also optionally utilized to quantify and/or detect the presence of a detectable label. In certain embodiments, one or more glycan residual compounds are optionally detected using a suitable liquid chromatography mass spectrometer (LC-MS).

In some embodiments, glycan residual compounds are tagged with an antibody or probe, and are quantified using any suitable method (e.g., dot blot techniques, immune detection techniques (e.g., ELISA), or the like).

Various analytical methods useful for the processes described herein include, by way of non-limiting example, mass spectrometry, chromatography, HPLC, UPLC, TLC, GC, HPAEC-PAD, electrophoresis—capillary or gel, or the like. In certain embodiments, wherein a chromatographic technique is utilized, any suitable solvent system is optionally employed. In certain embodiments, a column (e.g., Cosmogel DEAE, Tsk Gel DEAE, Cosmogel QA, Cosmogel CM, Cosmogel SP, or the like) is optionally loaded with an equilibrating solvent (e.g., a buffer or salt solution, such as a potassium acetate solution, sodium chloride solution, sodium acetate solution, ammonium acetate solution, or the like), e.g., with a pH of about 6, 7, or 8. In some embodiments, the buffer or salt solution has a concentration of about 10 mM, 20 mM, 30 mM, 50 mM, 100 mM, 500 mM, 1 M, 2 M, or the like. Any suitable flow rate is used, e.g., 0.5 mL/min, 1 mL, min, 1.5 mL/min, 2 mL/min, or the like. Following equilibration, a linear gradient is optionally utilized. In some embodiments, the linear gradient is run over 1-20 min, 1-10 min, 10-20 min, 1-5 min, 5-10 min, or the like. In certain embodiments, the gradient is a buffer or salt solution, e.g., as described above (e.g., from 0 M to 0.5 M, from 0 M to 3 M, from 0.5 M to 2 M, from 0 M to 2 M, from 1 M to 2 M, from 0 M to 3 M, from 2 M to 0 M, from 3 M to 0 M, or the like). Once the gradient has reached a final concentration, the eluent is optionally held at the final concentration for a suitable period of time (e.g., 1-20 min, 5-10 min, 10-15 min, 1-5 min, 1-10 min, 15-20 min, or the like). After the optional holding of the final concentration, the eluent may be switched to a second solvent or solvent system (e.g., an alcohol, such as methanol, ethanol, or isopropanol, acetonitrile, water, or the like). The switch to the second solvent system may be over a period of time, e.g., 15 seconds, 30 seconds, 45 seconds, 60 seconds, 2 min, 3 min, or the like. The second solvent system is optionally held for a period of time, such as 1 min, 2 min, 3 min, 4 min, 5 min, 6 min, or the like. Following the second solvent system cycle, the column is optionally restored to initial solvent conditions.

Purification:

In certain embodiments, methods described herein comprise purifying a biological sample, e.g., to remove non-glycan compounds from the biological sample. In some embodiments, a biological sample is purified prior to transforming a glycan thereof

In certain embodiments, a biological sample containing glycans (purified or not) can also be prepared so that all free glycan residual compounds (e.g., monosaccharides) that are naturally present in the biological sample (i.e., as taken from an individual and without being treated) are eliminated from the sample to reduce background signal (for example using dialysis, spin column, gel filtration, etc).

In some embodiments, any process described herein includes a step of purifying a biological sample comprising removing monosaccharides therefrom, removing sulfates therefrom, removing phosphates therefrom, removing acetate therefrom, removing sialic acid therefrom, or a combination thereof. For example, in some embodiments, a biological sample is optionally placed in to a defined MW cut off spin column (retains large molecules when spun), optionally washed (e.g., with 1 or more volumes of water or buffer), and/or the like.

In certain embodiments, purification of biological samples may further or alternatively comprise, e.g., fractionation, purification, enrichment, or the like of glycans contained therein. In some instances, such purification techniques are suitable to isolate and/or separate different glycan classes within the biological sample prior to transformation of one or more of such glycans. In more specific instances, such purification techniques are used to isolate and/or separate different subsets of a single glycan class (such as isolating complex N-linked glycans from hybrid N-linked structures) prior to transformation of one or more of such glycans. In certain embodiments, a biological sample is optionally prepared in such a way to enrich for specific glycan classes. For example, a PHA affinity column is optionally used to isolate a subfraction of complex N-linked glycans while a Con A column could be used to enrich in a different subset of N-linked glycans.

In some embodiments, any process described herein comprises purification of a glycan residual compound resulting from a process described herein (e.g., purification of the glycan residual compound prior to analysis thereof). For example, in some embodiments, the glycan residual compound is optionally isolated by any suitable process, such as by washing the free glycan residual compound (e.g., through a defined MW cut off membrane or by any other suitable method). Moreover, in certain embodiments, the resulting isolated glycan residual compound containing composition is optionally dried or otherwise treated to concentrate the sample and subsequently analyzed for glycan residual compound content by any suitable analytical technique.

In some embodiments, the processes described herein comprises further treatment steps of the test and/or control samples. For example, in some embodiments, the samples are homogenized and/or purified. In specific embodiments homogenization is achieved in any suitable manner including, by way of non-limiting example, with a basic solution, sonication, tissue grinding, or other chemical agents. In some embodiments, severity of a disorder is determined if a certain threshold amount is measured (e.g., as compared to a control or controls) or a threshold signal (e.g., on a fluorimeter or other analytical device utilized to detect and/or measure the generated biomarker). Similarly, a carrier of a disorder described herein is, in certain embodiments, determined if a certain threshold amount is measured (e.g., as compared to a control or controls) or a threshold signal (e.g., on a fluorimeter or other analytical device utilized to detect and/or measure the generated biomarker).

In certain embodiments, samples, including test samples and/or control samples, described herein are optionally purified prior to glycan processing (e.g., lyase treatment) and/or characterization. Test samples and/or control samples (i.e., one or more or all of the glycans found therein) are optionally purified using any suitable purification technique. Test samples and/or control samples are optionally purified at any suitable point in a process described herein, including before or after tagging of the glycans founds within the sample. In certain embodiments, purification techniques include centrifugation, electrophoresis, chromatography (e.g., silica gel or alumina column chromatography), gas chromatography, high performance liquid chromatography (HPLC) (e.g., reverse phase HPLC on chiral or achiral columns), thin layer chromatography, ion exchange chromatography, gel chromatography (e.g., gel filtration or permeation or size exclusion chromatography, gel electrophoresis), molecular sieve chromatography, affinity chromatography, size exclusion, filtration (e.g. through a florisil or activated charcoal plug), precipitation, osmosis, recrystallization, fluorous phase purification, distillation, extraction, chromatofocusing, supercritical fluid extraction, preparative flash chromatography (e.g., flash chromatography using a UV-Vis detector and/or a mass spectrometer (e.g., using the Biotage® suite of products) or the like.

In some embodiments, glycans, such as heparan sulfate, are naturally found attached to a core protein (together forming a proteoglycan) or a lipid. In some embodiments, provided herein are purification processes of separating glycan fragments (e.g., heparan sulfate fragments) from proteoglycans or glycolipids prior to processing the glycan for processing and analysis.

Monitoring Therapy

Provided in certain embodiments are methods of treating disorders associated with the abnormal degradation, biosynthesis and/or accumulation of glycans, the methods comprising:

a. administering an agent for treating disorders associated with the abnormal degradation, biosynthesis and/or accumulation of glycans (e.g., an anti-LSD agent, an anti-cancer agent, or the like) to an individual in need thereof;

b. monitoring the accumulation of glycans in the individual using any process described herein for detecting or quantifying the amount of glycan residual compounds (e.g., mono-saccharides, sulfate, or the like) present in a lyase digested biological sample (e.g., urine, serum, plasma, or CSF sample) according to any process described herein.

Provided in further or alternative embodiments are methods of monitoring the treatment of disorders associated with the abnormal degradation, biosynthesis and/or accumulation of glycans, the methods comprising the following steps:

a. following administration of an agent for treating a disorder associated with the abnormal degradation, biosynthesis and/or accumulation of glycans (e.g., an anti-LSD agent, an anti-cancer agent, or the like) to an individual in need thereof, generating a biomarker comprising of one or more non-reducing end glycan residual compound (e.g., monosaccharide).

In some embodiments, the biomarker is a saturated monosaccharide and is generated by treating a population of glycans, in or isolated from a biological sample from the individual, with at least one digesting glycan enzymes, wherein prior to enzyme treatment, the biomarker is not present in abundance in samples from individuals with the disease or condition relative to individuals without the disease or condition. In certain embodiments, monitoring of the accumulation of glycans comprises using an analytical instrument to detect the presence of and/or measure the amount of the biomarker produced and displaying or recording the presence of or a measure of a population of the biomarker; wherein the presence of and/or measure the amount of the biomarker is utilized to monitor the treatment.

In some embodiments, the agent is administered one or more times. In certain embodiments, the agent is administered multiple times. In some embodiments, the agent is administered in a loading dose one or more times (e.g., in a loading dosing schedule) and subsequently administered in a maintenance dose (e.g., in a maintenance dosing schedule, such as three times a day, twice a day, once a day, once every two days, once every three days, once every four days, once a week, or the like). In some embodiments, when glycan (as measure by one or more glycan residual compound(s)) accumulation begins to increase or accelerate, the dose is optionally adjusted (e.g., the maintenance dose is increased, or an additional loading dose or dosing schedule is utilized).

In some embodiments, monitoring the accumulation of glycans comprises repeating the step of: using an analytical instrument to detect the presence of and/or measure the amount of a population of one or more glycan residual compounds present in a transformed biological sample that has been prepared by treating a population of glycans, in or isolated from a biological sample from the individual, with at least one digesting glycan lyase to transform the glycan into the population of the one or more glycan residual compounds. In specific embodiments, the step is repeated at periodic intervals (e.g., every day, every other day, every 2 days, every 3 days, every 4 days, every week, every month, every 3 months, quarterly, every 6 months, yearly, or the like), at regular times following a dose (e.g., 4 hours after a administration of the agent, 6 hours after administration of the agent, 8 hours after administration of the agent, 12 hours after administration of the agent, or the like), prior to administration of the dose (e.g., immediately prior to administration of the agent, 2 hours prior to administration of the agent, or the like), or any other monitoring schedule.

In some embodiments, the monitoring of the accumulation of glycan is conducted over a period of time, e.g., over a week, two weeks, a month, two months, three months, six months, a year, or the like. In some embodiments, the method for quantifying the amount of one or more glycan residual compounds in a lyase digested biological sample (e.g., urine, serum, plasma, or CSF) comprises detecting and/or measuring (e.g., with an analytical device), one or more glycan residual compounds within the lyase digested biological sample from the individual after the biological sample obtained from the individual has been treated with one or more glycan lyases. In certain embodiments, such glycan lyases are suitable for preparing glycan residual compounds from the glycan present in the biological sample obtained from the individual. In certain instances a representative portion of the one or more glycan residual compounds in the transformed biological sample is tagged with any suitable detectable label (e.g., a mass label, a radioisotope label, a fluorescent label, a chromophore label, affinity label, an antibody). In some embodiments, the process comprises displaying or recording such a characterization of the population of glycan residual compounds and/or tagged glycan residual compounds.

In some embodiments, the agent described in a therapy herein includes glycan accumulation inhibitors, agents that promote glycan degradation, agents that activate enzymes that degrade glycans, agents that inhibit biosynthesis of glycans, or the like. In some embodiments, the agent that modulates glycan biosynthesis is an agent that selectively modulates heparan sulfate biosynthesis, an agent that selectively modulates chondroitin sulfate biosynthesis, an agent that selectively modulates dermatan sulfate biosynthesis, an agent that selectively modulates keratan sulfate biosynthesis, an agent that selectively modulates hyaluronan biosynthesis, or a combination thereof. Anti-LSD drugs include, by way of non-limiting example, Imiglucerase (Cerazyme), laronidase (Aldurazyme), idursulfase (Elaprase), galsulfase (Naglazyme), agalsidase beta (Fabrazyme), alglucosidase alfa (Myozyme), agalsidase alfa (Replagal), miglustat (Zavesca).

In some embodiments, one or more of the anti-cancer agents are proapoptotic agents. Examples of anti-cancer agents include, by way of non-limiting example: gossyphol, genasense, polyphenol E, Chlorofusin, all trans-retinoic acid (ATRA), bryostatin, tumor necrosis factor-related apoptosis-inducing ligand (TRAIL), 5-aza-2'-deoxycytidine, all trans retinoic acid, doxorubicin, vincristine, etoposide, gemcitabine, imatinib (Gleevec®), geldanamycin, 17-N-Allylamino-17-Demethoxygeldanamycin (17-AAG), flavopiridol, LY294002, bortezomib, trastuzumab, BAY 11-7082, PKC412, or PD184352, Taxol™, also referred to as "paclitaxel", which is a well-known anti-cancer drug which acts by enhancing and stabilizing microtubule formation, and analogs of Taxol™, such as Taxotere™. Compounds that have the basic taxane skeleton as a common structure feature, have also been shown to have the ability to arrest cells in the G2-M phases due to stabilized microtubules and may be useful for treating cancer in combination with the compounds described herein.

Further examples of anti-cancer agents include inhibitors of mitogen-activated protein kinase signaling, e.g., U0126, PD98059, PD184352, PD0325901, ARRY-142886, SB239063, SP600125, BAY 43-9006, wortmannin, or LY294002; Syk inhibitors; mTOR inhibitors; and antibodies (e.g., rituxan).

Other anti-cancer agents include Adriamycin, Dactinomycin, Bleomycin, Vinblastine, Cisplatin, acivicin; aclarubicin; acodazole hydrochloride; acronine; adozelesin; aldesleukin; altretamine; ambomycin; ametantrone acetate; aminoglutethimide; amsacrine; anastrozole; anthramycin; asparaginase; asperlin; azacitidine; azetepa; azotomycin; batimastat; benzodepa; bicalutamide; bisantrene hydrochloride; bisnafide dimesylate; bizelesin; bleomycin sulfate; brequinar sodium; bropirimine; busulfan; cactinomycin; calusterone; caracemide; carbetimer; carboplatin; carmustine; carubicin hydrochloride; carzelesin; cedefingol; chlorambucil; cirolemycin; cladribine; crisnatol mesylate; cyclophosphamide; cytarabine; dacarbazine; daunorubicin hydrochloride; decitabine; dexormaplatin; dezaguanine; dezaguanine mesylate; diaziquone; doxorubicin; doxorubicin hydrochloride; droloxifene; droloxifene citrate; dromostanolone propionate; duazomycin; edatrexate; eflornithine hydrochloride; elsamitrucin; enloplatin; enpromate; epipropidine; epirubicin hydrochloride; erbulozole; esorubicin hydrochloride; estramustine; estramustine phosphate sodium; etanidazole; etoposide; etoposide phosphate; etoprine; fadrozole hydrochloride; fazarabine; fenretinide; floxuridine; fludarabine phosphate; fluorouracil; flurocitabine; fosquidone; fostriecin sodium; gemcitabine; gemcitabine hydrochloride; hydroxyurea; idarubicin hydrochloride; ifosfamide; iimofosine; interleukin Il (including recombinant interleukin II, or rIL2), interferon alfa-2a; interferon alfa-2b; interferon alfa-n1; interferon alfa-n3; interferon beta-1 a; interferon gamma-1 b; iproplatin; irinotecan hydrochloride; lanreotide acetate; letrozole; leuprolide acetate; liarozole hydrochloride; lometrexol sodium; lomustine; losoxantrone hydrochloride; masoprocol; maytansine; mechlorethamine hydrochloride; megestrol acetate; melengestrol acetate; melphalan; menogaril; mercaptopurine; methotrexate; methotrexate sodium; metoprine; meturedepa; mitindomide; mitocarcin; mitocromin; mitogillin; mitomalcin; mitomycin; mitosper; mitotane; mitoxantrone hydrochloride; mycophenolic acid; nocodazoie; nogalamycin; ormaplatin; oxisuran; pegaspargase; peliomycin; pentamustine; peplomycin sulfate; perfosfamide; pipobroman; piposulfan; piroxantrone hydrochloride; plicamycin; plomestane; porfimer sodium; porfiromycin; prednimustine; procarbazine hydrochloride; puromycin; puromycin hydrochloride; pyrazofurin; riboprine; rogletimide; safingol; safingol hydrochloride; semustine; simtrazene; sparfosate sodium; sparsomycin; spirogermanium hydrochloride; spiromustine; spiroplatin; streptonigrin; streptozocin; sulofenur; talisomycin; tecogalan sodium; tegafur; teloxantrone hydrochloride; temoporfin; teniposide; teroxirone; testolactone; thiamiprine; thioguanine; thiotepa; tiazofurin; tirapazamine; toremifene citrate; trestolone acetate; triciribine phosphate; trimetrexate; trimetrexate glucuronate; trip-

torelin; tubulozole hydrochloride; uracil mustard; uredepa; vapreotide; verteporfin; vinblastine sulfate; vincristine sulfate; vindesine; vindesine sulfate; vinepidine sulfate; vinglycinate sulfate; vinleurosine sulfate; vinorelbine tartrate; vinrosidine sulfate; vinzolidine sulfate; vorozole; zeniplatin; zinostatin; zorubicin hydrochloride.

Other anti-cancer agents include: 20-epi-1, 25 dihydroxyvitamin D3; 5-ethynyluracil; abiraterone; aclarubicin; acylfulvene; adecypenol; adozelesin; aldesleukin; ALL-TK antagonists; altretamine; ambamustine; amidox; amifostine; aminolevulinic acid; amrubicin; amsacrine; anagrelide; anastrozole; andrographolide; angiogenesis inhibitors; antagonist D; antagonist G; antarelix; anti-dorsalizing morphogenetic protein-1; antiandrogen, prostatic carcinoma; antiestrogen; antineoplaston; antisense oligonucleotides; aphidicolin glycinate; apoptosis gene modulators; apoptosis regulators; apurinic acid; ara-CDP-DL-PTBA; arginine deaminase; asulacrine; atamestane; atrimustine; axinastatin 1; axinastatin 2; axinastatin 3; azasetron; azatoxin; azatyrosine; baccatin III derivatives; balanol; batimastat; BCR/ABL antagonists; benzochlorins; benzoylstaurosporine; beta lactam derivatives; beta-alethine; betaclamycin B; betulinic acid; bFGF inhibitor; bicalutamide; bisantrene; bisaziridinylspermine; bisnafide; bistratene A; bizelesin; breflate; bropirimine; budotitane; buthionine sulfoximine; calcipotriol; calphostin C; camptothecin derivatives; canarypox IL-2; capecitabine; carboxamide-amino-triazole; carboxyamidotriazole; CaRest M3; CARN 700; cartilage derived inhibitor; carzelesin; casein kinase inhibitors (ICOS); castanospermine; cecropin B; cetrorelix; chlorins; chloroquinoxaline sulfonamide; cicaprost; cis-porphyrin; cladribine; clomifene analogues; clotrimazole; collismycin A; collismycin B; combretastatin A4; combretastatin analogue; conagenin; crambescidin 816; crisnatol; cryptophycin 8; cryptophycin A derivatives; curacin A; cyclopentanthraquinones; cycloplatam; cypemycin; cytarabine ocfosfate; cytolytic factor; cytostatin; dacliximab; decitabine; dehydrodidemnin B; deslorelin; dexamethasone; dexifosfamide; dexrazoxane; dexverapamil; diaziquone; didemnin B; didox; diethylnorspermine; dihydro-5-azacytidine; 9-dioxamycin; diphenyl spiromustine; docosanol; dolasetron; doxifluridine; droloxifene; dronabinol; duocarmycin SA; ebselen; ecomustine; edelfosine; edrecolomab; eflornithine; elemene; emitefur; epirubicin; epristeride; estramustine analogue; estrogen agonists; estrogen antagonists; etanidazole; etoposide phosphate; exemestane; fadrozole; fazarabine; fenretinide; filgrastim; finasteride; flavopiridol; flezelastine; fluasterone; fludarabine; fluorodaunorunicin hydrochloride; forfenimex; formestane; fostriecin; fotemustine; gadolinium texaphyrin; gallium nitrate; galocitabine; ganirelix; gelatinase inhibitors; gemcitabine; glutathione inhibitors; hepsulfam; heregulin; hexamethylene bisacetamide; hypericin; ibandronic acid; idarubicin; idoxifene; idramantone; ilmofosine; ilomastat; imidazoacridones; imiquimod; immunostimulant peptides; insulin-like growth factor-1 receptor inhibitor; interferon agonists; interferons; interleukins; iobenguane; iododoxorubicin; ipomeanol, 4-; iroplact; irsogladine; isobengazole; isohomohalicondrin B; itasetron; jasplakinolide; kahalalide F; lamellarin-N triacetate; lanreotide; leinamycin; lenograstim; lentinan sulfate; leptolstatin; letrozole; leukemia inhibiting factor; leukocyte alpha interferon; leuprolide+estrogen+progesterone; leuprorelin; levamisole; liarozole; linear polyamine analogue; lipophilic disaccharide peptide; lipophilic platinum compounds; lissoclinamide 7; lobaplatin; lombricine; lometrexol; lonidamine; losoxantrone; lovastatin; loxoribine; lurtotecan; lutetium texaphyrin; lysofylline; lytic peptides; maitansine; mannostatin A; marimastat; masoprocol; maspin; matrilysin inhibitors; matrix metalloproteinase inhibitors; menogaril; merbarone; meterelin; methioninase; metoclopramide; MIF inhibitor; mifepristone; miltefosine; mirimostim; mismatched double stranded RNA; mitoguazone; mitolactol; mitomycin analogues; mitonafide; mitotoxin fibroblast growth factor-saporin; mitoxantrone; mofarotene; molgramostim; monoclonal antibody, human chorionic gonadotrophin; monophosphoryl lipid A+myobacterium cell wall sk; mopidamol; multiple drug resistance gene inhibitor; multiple tumor suppressor 1-based therapy; mustard anticancer agent; mycaperoxide B; mycobacterial cell wall extract; myriaporone; N-acetyldinaline; N-substituted benzamides; nafarelin; nagrestip; naloxone+pentazocine; napavin; naphterpin; nartograstim; nedaplatin; nemorubicin; neridronic acid; neutral endopeptidase; nilutamide; nisamycin; nitric oxide modulators; nitroxide antioxidant; nitrullyn; O6-benzylguanine; octreotide; okicenone; oligonucleotides; onapristone; ondansetron; ondansetron; oracin; oral cytokine inducer; ormaplatin; osaterone; oxaliplatin; oxaunomycin; palauamine; palmitoylrhizoxin; pamidronic acid; panaxytriol; panomifene; parabactin; pazelliptine; pegaspargase; peldesine; pentosan polysulfate sodium; pentostatin; pentrozole; perflubron; perfosfamide; perillyl alcohol; phenazinomycin; phenylacetate; phosphatase inhibitors; picibanil; pilocarpine hydrochloride; pirarubicin; piritrexim; placetin A; placetin B; plasminogen activator inhibitor; platinum complex; platinum compounds; platinum-triamine complex; porfimer sodium; porfiromycin; prednisone; propyl bis-acridone; prostaglandin J2; proteasome inhibitors; protein A-based immune modulator; protein kinase C inhibitor; protein kinase C inhibitors, microalgal; protein tyrosine phosphatase inhibitors; purine nucleoside phosphorylase inhibitors; purpurins; pyrazoloacridine; pyridoxylated hemoglobin polyoxyethylerie conjugate; raf antagonists; raltitrexed; ramosetron; ras farnesyl protein transferase inhibitors; ras inhibitors; ras-GAP inhibitor; retelliptine demethylated; rhenium Re 186 etidronate; rhizoxin; ribozymes; RII retinamide; rogletimide; rohitukine; romurtide; roquinimex; rubiginone B1; ruboxyl; safingol; saintopin; SarCNU; sarcophytol A; sargramostim; Sdi 1 mimetics; semustine; senescence derived inhibitor 1; sense oligonucleotides; signal transduction inhibitors; signal transduction modulators; single chain antigen-binding protein; sizofiran; sobuzoxane; sodium borocaptate; sodium phenylacetate; solverol; somatomedin binding protein; sonermin; sparfosic acid; spicamycin D; spiromustine; splenopentin; spongistatin 1; squalamine; stem cell inhibitor; stem-cell division inhibitors; stipiamide; stromelysin inhibitors; sulfinosine; superactive vasoactive intestinal peptide antagonist; suradista; suramin; swainsonine; synthetic glycosaminoglycans; tallimustine; tamoxifen methiodide; tauromustine; tazarotene; tecogalan sodium; tegafur; tellurapyrylium; telomerase inhibitors; temoporfin; temozolomide; teniposide; tetrachlorodecaoxide; tetrazomine; thaliblastine; thiocoraline; thrombopoietin; thrombopoietin mimetic; thymalfasin; thymopoietin receptor agonist; thymotrinan; thyroid stimulating hormone; tin ethyl etiopurpurin; tirapazamine; titanocene bichloride; topsentin; toremifene; totipotent stem cell factor; translation inhibitors; tretinoin; triacetyluridine; triciribine; trimetrexate; triptorelin; tropisetron; turosteride; tyrosine kinase inhibitors; tyrphostins; UBC inhibitors; ubenimex; urogenital sinus-derived growth inhibitory factor; urokinase receptor antagonists; vapreotide; variolin B; vector system, erythrocyte gene therapy; velaresol; veramine; verdins; verteporfin; vinorelbine; vinxaltine; vitaxin; vorozole; zanoterone; zeniplatin; zilascorb; and zinostatin stimalamer.

Yet other anticancer agents that include alkylating agents, antimetabolites, natural products, or hormones, e.g., nitrogen mustards (e.g., mechloroethamine, cyclophosphamide, chlorambucil, etc.), alkyl sulfonates (e.g., busulfan), nitrosoureas (e.g., carmustine, lomusitne, ete.), or triazenes (decarbazine, etc.). Examples of antimetabolites include but are not limited to folic acid analog (e.g., methotrexate), or pyrimidine analogs (e.g., Cytarabine), purine analogs (e.g., mercaptopurine, thioguanine, pentostatin).

Examples of natural products include but are not limited to vinca alkaloids (e.g., vinblastin, vincristine), epipodophyllotoxins (e.g., etoposide), antibiotics (e.g., daunorubicin, doxorubicin, bleomycin), enzymes (e.g., L-asparaginase), or biological response modifiers (e.g., interferon alpha).

Examples of alkylating agents include, but are not limited to, nitrogen mustards (e.g., mechloroethamine, cyclophosphamide, chlorambucil, meiphalan, etc.), ethylenimine and methylmelamines (e.g., hexamethlymelamine, thiotepa), alkyl sulfonates (e.g., busulfan), nitrosoureas (e.g., carmustine, lomusitne, semustine, streptozocin, etc.), or triazenes (decarbazine, ete.). Examples of antimetabolites include, but are not limited to folic acid analog (e.g., methotrexate), or pyrimidine analogs (e.g., fluorouracil, floxouridine, Cytarabine), purine analogs (e.g., mercaptopurine, thioguanine, pentostatin.

Examples of hormones and antagonists include, but are not limited to, adrenocorticosteroids (e.g., prednisone), progestins (e.g., hydroxyprogesterone caproate, megestrol acetate, medroxyprogesterone acetate), estrogens (e.g., diethlystilbestrol, ethinyl estradiol), antiestrogen (e.g., tamoxifen), androgens (e.g., testosterone propionate, fluoxymesterone), antiandrogen (e.g., flutamide), gonadotropin releasing hormone analog (e.g., leuprolide). Other agents that can be used in the methods and compositions described herein for the treatment or prevention of cancer include platinum coordination complexes (e.g., cisplatin, carboblatin), anthracenedione (e.g., mitoxantrone), substituted urea (e.g., hydroxyurea), methyl hydrazine derivative (e.g., procarbazine), adrenocortical suppressant (e.g., mitotane, aminoglutethimide).

In some instances, the detection and/or the quantification of the identity and/or amount of glycan residual compounds present in a biological sample is used to identify and/or diagnose a disorder associated with abnormal degradation, biosynthesis and/or accumulation of glycan in an individual suspected of having such a disorder.

In some instances, the detection and/or the quantification of the identity and/or amount of glycan residual compounds present in the biological sample is used to monitor severity and course of the disease in an individual diagnosed with or suspected of having a disorder associated with the abnormal degradation, biosynthesis and/or accumulation of glycans. In some instances, the detection and/or the quantification of the identity and/or amount of glycan residual compounds present in the biological sample is used to calculate the administered dose of an agent that modulates (e.g., promotes and/or inhibits) glycan biosynthesis and/or degradation.

In certain instances, wherein following administration of a selected dose of a therapeutic agent utilized in a therapeutic method described herein, an individual's condition does not improve, the detection and/or the quantification of the identity and/or amount of glycan residual compounds present in a biological sample provides for a treatment regimen to be modified depending on the severity and course of the disease, disorder or condition, previous therapy, the individual's health status and response to the drugs, and the judgment of the treating physician.

In certain embodiments, monitoring the accumulation of glycans in the individual comprises detecting or quantifying the amount of an glycan residual compounds (or one or more glycan residual compounds) in a sample obtained from the individual (e.g., according to any method described herein) to obtain a first accumulation result (e.g., an initial reading before treatment has begun, or at any other time) and a second accumulation result that is subsequent to obtaining the first result. In some embodiments, the second result is compared to the first result to determine if the treatment is effectively reducing, maintaining, or reducing the rate of increasing the glycan residual compounds levels in a substantially identically obtained sample from the individual being treated. In certain embodiments, depending on the difference between the first and second results, the treatment can be altered, e.g., to increase or decrease the amount of agent administered; to substitute the therapeutic agent with an alternative therapeutic agent; or the like. In certain embodiments, the dose of the therapeutic agent is decreased to a maintenance level (e.g., if the glycan residual compound level has been reduced sufficiently); further monitoring of glycan residual compound levels is optional in such situation, e.g., to ensure that reduced or maintained levels of glycan residual compounds (e.g., monosaccharide(s)) are achieved.

Alternatively, provided herein is a method of detecting response to therapy in an individual or a method of predicting response to therapy in an individual comprising:

a. administering an agent for treating a disorder associated with the abnormal degradation, biosynthesis and/or accumulation of glycans to a plurality of cells from an individual in need thereof (e.g., a plurality of fibroblasts, serum, plasma, or CSF cells from a human suffering from a disorder associated with the abnormal degradation, biosynthesis and/or accumulation of glycans, such as an LSD or cancer);
b. monitoring the accumulation of glycans in the plurality of cells using any process described herein for detecting or quantifying the amount of glycan residual compounds (e.g., monosaccharides, sulfate, sialic acid, phosphate, acetate, or the like) present in a lyase digested biological sample from the plurality of cells according to any process described herein.

In specific embodiments, the glycan residual compound(s) detected or measured is one or more monosaccharide. It is to be understood that a plurality of cells from an individual includes cells that are directly taken from the individual, and/or cells that are taken from an individual followed by culturing to expand the population thereof.

EXAMPLES

Example 1

To illustrate the methods described herein, we have used human urine sample from normal patients and patients diagnosed with MPS IIIA. MPS IIIA patients have reduced function of the lysosomal enzyme that de-N-sulfates the nonreducing end glucosamine residues present in heparan sulfate. This unique nonreducing end glycan residual (N-sulfated GlcN) can be liberated by treating the glycans with heparin lyases and quantified by fluorescent detection on HPLC. As shown below, glycans prepared in this manner from normal individuals lack N-sulfate GlcN while MPS IIIA patients have a very high level.

Purification: The biological sample (cells, tissue, blood, serum, or the like) is homogenized and solubilzed in 0.1-1.0 N NaOH (e.g., 0.1 N, 0.2 N, 0.3 N, 0.4 N, 0.5 N, 0.6 N, 0.7 N,

0.8 N, 0.9 N, or 1.0 N) or acetic acid and then neutralized with acetic acid or NaOH. Next a small sample is taken to measure protein content of the sample using standard methods. 0.01-0.5 mg/mL (0.01 mg/mL, 0.07 mg/mL, 0.12 mg/mL, 0.17 mg/mL, 0.22 mg/mL, 0.27 mg/mL, 0.32 mg/mL, 0.37 mg/mL, 0.42 mg/mL, or 0.5 mg/mL) protease (trypsin, chymotrypsin, pepsin, pronase, papain, or elastase) is treated in 0.1-0.5 M (e.g., 0.1 M, 0.16 M, 0.23 M, 0.32 M, 0.39 M, 0.44 M, or 0.5 M) NaCl, 0.01-0.1 M (e.g., 0.01 M, 0.02 M, 0.04 M, 0.06 M, 0.08 M, 0.1 M) NaOAc, at pH 5.5-7.5 (e.g., 5.5, 6.0, 6.5, 7.0, or 7.5) and 25-40 C (e.g., 25 C, 30 C, 35 C, or 40 C) for 1-24 hours (e.g., 1 h, 2 h, 4 h, 6 h, 8 h, 12 h, 18 h, 24 h). The sample is diluted to reduce the ionic strength and loaded onto an ion exchange column in 5-100 mM (e.g., 5 mM, 10 mM, 20 mM, 30 mM, 40 mM, 50 mM, 60 mM, 70 mM, 75 mM, 80 mM, 90 mM, 95 mM, 100 mM) NaOAc pH 5-7 with 0-300 mM NaCl. After washing, the bound glycosaminoglycans are eluted with 5-100 mM NaOAc pH 5-7 (e.g., 5, 5.5, 6, 6.5, 7) with 0.8-3 M (e.g., 0.8 M, 1 M, 1.2 M, 1.4 M, 1.6 M, 1.8 M, 2 M, 2.5 M, or 3 M) NaCl. The eluted glycans are then concentrated and desalted by ethanol precipitation, size exclusion, or other methods. The purified glycans are dried for further analysis.

Liberation of non-reducing end residual: The purified glycans are resuspended in 10-300 mM sodium acetate, tris, phosphate, or other suitable buffer, 0.02-1 mM (e.g., 0.02, 0.04, 0.06, 0.08, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, or 1) calcium acetate, pH 5-8 (e.g., 5, 5.5, 6, 6.5, 7, 7.5, or 8), were digested with heparin lyases I, II, III, I and II, I and III, II and III, or I, II, and III (0.0.15-1.5 milliunits of each in 100-ul reactions, IBEX, Montreal, Canada) at 25 to 37° C. for 1 to 24 hours.

Fluorescent tagging of glycan residual: Dried glycan sample is re-suspended in 2-100 μL 0.003-0.1 M (e.g., 0.003 M, 0.003 M, 0.03 M, 0.06 M, 0.1 M) AB, AA, AMAC, or Bodipy dye and incubated at room temperature for 1-120 minutes (e.g., 1-10 min, 10-15 min, 15-20 min, 20-25 min, 25-30 min, 30-40 min, 40-50 min, 50-60 min, 60-90 min, 90-120 min). Next, the reaction is initiated with 2-100 μL (2 μL, 5 μL, 10 μL, 15 μL, 20 μL, 25 μL, 30 μL, 40 μL, 50 μL, 60 μL, 70 μL, 80 μL, 90 μL, or 100 μL) 1 M $NaCNBH_4$ and the reaction is allowed to proceed at 25-100 C. (e.g., 25 C, 30 C, 35 C, 40 C, 50 C, 60 C, 70 C, 80 C, 90 C, 100 C).

Detection of glycan residual: HPLC separation of tagged saccharides was performed utilizing the following conditions: Column types: 130A BEH particle Phenyl (1.7, 2.5, 3.5, 5, or 10 uM particle size), 130 A BEH particle C18 (1.7, 2.5, 3.5, 5, or 10 uM particle size), HSS particle C18 (1.8, 3.5, or 5 uM particle size), or 300A BEH particle C18 (1.7, 3.5, 5, 10 uM particle size) with suitable length and internal diameter.

Buffer Conditions:

A=Ammonium Acetate, Sodium Acetate, or Sodium Chloride (e.g., 0 M, 10 mM, 20 mM, 30 mM, 40 mM, 100 mM, 500 mM, 1 M, 2 M) with 0-20% methanol

B=100% Alcohol, such as methanol, ethanol, or isopropanol

Initial Conditions: 70-95% A, 0-30% B

Flow Rate is constant at 0.05-1 ml/min

Runs a gradient down to 70-90% A, 10-30% B over 5-65 min.

At 8.1 min runs a gradient to 0-20% A, 80-100% B over 5-20 min.

5-65 min returns to initial conditions

FIG. **1** illustrates an HPLC trace of eluted compounds detected in normal patient urine not subject to enzymatic glycan residual liberation (i.e., providing background signals). FIG. **2** illustrates an HPLC trace of eluted compounds detected in normal patient urine subject to enzymatic glycan residual liberation as set forth in Example 1. FIG. **3** illustrates an HPLC trace of eluted compounds detected in MPS IIIA patient urine not subject to enzymatic glycan residual liberation (i.e., providing background signals). FIG. **4** illustrates an HPLC trace of eluted compounds detected in MPS IIIA patient urine subject to enzymatic glycan residual liberation.

Example 2

The processes described in Example 1 are repeated and/or modified for the diseases listed in Tables 1-4 utilizing the enzymes described there in and detecting the glycan residual compounds also described therein.

What is claimed is:

1. A method of determining the presence, identity, and/or severity of a disease or condition in an individual, where the disease or condition is associated with abnormal glycan biosynthesis, degradation, or accumulation, the method comprising:

(a) generating a biomarker comprising of one or more non-reducing end glycan residual compound(s), wherein the biomarker is generated by treating a population of glycans, in or isolated from a biological sample from the individual, with at least one digesting glycan enzyme(s), wherein prior to enzyme treatment, the biomarker is not present in abundance in samples from individuals with the disease or condition relative to individuals without the disease or condition, and

(b) detecting the presence of and/or measuring the amount of the biomarker produced using an analytical instrument and displaying or recording the presence of or the measure of the biomarker produced;

(c) correlating the presence of and/or the measure of the amount of the biomarker with the presence, identity, and/or severity of the disease or condition for determining the presence, identity, and/or severity of the disease or condition;

wherein the disease or condition is a lysosomal storage disease, cancer, an inflammatory disease, a liver disease, a bone disease, an infectious disease, a central nervous system disease, or a cardiovascular disease; and

wherein when the lysosomal storage disease is an MPS disorder or when the disease or condition is osteoarthritis, then the digesting glycan enzyme is not a lyase.

2. The method of claim **1**, wherein the disease or condition is caused by an abnormally functioning glycan degradation enzyme.

3. The method of claim **1**, wherein at least one of the digesting glycan enzymes is selected from a sialidase, hexosaminidase, fucosidase, N-acetyl-transferase, glycosidase, sulfatase, phosphorylase, deacetylase, or a combination thereof.

4. The method of claim **3**, wherein at least one of the non-reducing end glycan residual compounds is a monosaccharide or wherein at least one of the non-reducing end glycan residual compounds is sulfate, phosphate, acetate, or a combination thereof.

5. The method of claim **1**, further comprising purifying the biological sample prior to enzyme treatment.

6. The method of claim **1**, wherein the disease or condition associated with an abnormal glycan accumulation is MPS I, MPS II, MPS IIIA, MPS IIIB, MPS IIIC, MPS IIID, MPS IVA, MPS IVB, MPS VI, or MPS VII.

7. The method of claim **6**, wherein the disease, condition or disorder is:

(i) MPS I and at least one of the digesting glycan enzymes is an iduronidase;

(ii) MPS II and at least one of the digesting glycan enzymes is a 2-sulfatase;

(iii) MPS IIIA and at least one of the digesting glycan enzymes is an N-sulfatase;

(iv) MPS IIIB and at least one of the digesting glycan enzymes is a hexosaminidase or a deacetylase;

(v) MPS IIIC and at least one of the digesting glycan enzymes is hexosaminidase or an N-acetyl-transferase;

(vi) MPS IIID and at least one of the digesting glycan enzymes is 6-O-sulfatase;

(vii) MPS IVA and at least one of the digesting glycan enzymes is a 6-O-sulfatase, galactosidase, N-acetyl-galactosidase, or hexosaminidase;

(viii) MPS IVB and at least one of the digesting glycan enzymes is a galactosidase;

(ix) MPS VI and at least one of the digesting glycan enzymes is 4-O-sulfatase; or (x) MPS VII and at least one of the digesting glycan enzymes is β-glucuronidase.

8. The method of claim **1**, wherein the biomarker is a glycan residue and is labeled with a detectable label and the amount of the biomarker is measured with an analytical instrument to determine whether the amount is abnormal.

9. The method of claim **1**, wherein the disease, condition or disorder is alpha mannodidosis, aspartylglucoaminuria, Fabry's disease, fucosidosis, galatosialidosis, Gaucher disease, GM1 gangliosidosis, GM2 activator deficiency, sialidosis, Krabbe disease, metachromatic leukodystrophy, mucolipidosis II, mucolipidosis III, mucolipodosis IV, multiple sulfatase deficiency, Pompe disease, Sandhoff disease, Tay-Sachs disease, AB variant, Schindler disease, alpha mannosidosis, beta mannosidosis, or globoid cell leukodystrophy.

10. The method of claim **9** wherein the disease, condition or disorder is:

(i) alpha mannodidosis and at least one of the digesting glycan enzymes is a mannosidase;

(ii) aspartylglucoaminuria and at least one of the digesting glycan enzymes is hexosaminidase;

(iii) Fabry's disease and at least one of the digesting glycan enzymes is a galactosidase;

(iv) fucosidosis and at least one of the digesting glycan enzymes is a fucosidase;

(v) galatosialidosis and at least one of the digesting glycan enzymes is a galactosidase and/or a sialidase;

(vi) Gaucher disease and at least one of the digesting glycan enzymes is a glucosidase;

(vii) GM1 gangliosidosis and at least one of the digesting glycan enzymes is β-galactosidase;

(viii) GM2 activator deficiency and at least one of the digesting glycan enzymes is hexosaminidase;

(ix) sialidosis and at least one of the digesting glycan enzymes is a sialidase;

(x) Krabbe disease and at least one of the digesting glycan enzymes is a galactosidase;

(xi) metachromatic leukodystrophy and at least one of the digesting glycan enzymes is 3-O-sulfatase;

(xii) mucolipidosis II and at least one of the digesting glycan enzymes is any listed enzyme in Table 1;

(xiii) mucolipidosis III and at least one of the digesting glycan enzymes is any listed enzyme in Table 1;

(xiv) mucolipidosis IV and at least one of the digesting glycan enzymes is any listed enzyme in Table 1;

(xv) multiple sulfatase deficiency and at least one of the digesting glycan enzymes is a sulfatase or glycosidase;

(xvi) Pompe disease and at least one of the digesting glycan enzymes is glucosidase;

(xvii) Sandhoff disease and at least one of the digesting glycan enzymes is hexosaminidase;

(xviii) Tay-Sachs disease and at least one of the digesting glycan enzymes is hexosaminidase;

(xix) AB variant and at least one of the digesting glycan enzymes is hexosaminidase;

(xx) Schindler disease and at least one of the digesting glycan enzymes is hexosaminidase;

(xxi) alpha mannosidosis and at least one of the digesting glycan enzymes is mannosidase;

(xxii) beta mannosidosis and at least one of the digesting glycan enzymes is mannosidase; or

(xxiii) globoid cell leukodystrophy and at least one of the digesting glycan enzymes is galactosidase.

11. The method of claim **1**, wherein

(i) the infectious disease is a bacterial or fungal infection and at least one of the digesting enzymes is a mannosidase, fucosidase, glucosidase, galactosidase, hexosaminidase, arabinosidase, xylosidase, ribosidase, lyxosidase, talosidase, idosidase, gulosidase, altrosidase, or allosidase;

(ii) the infectious disease is a viral infection and at least one of the digesting enzymes is a sialidase, α-sialidase, hexosaminidase, galactosidase, fucosidase, or sulfatase; where the disease is coronary artery disease and at least one of the digesting enzymes is a sialidase, α-sialidase, hexosaminidase, galactosidase, fucosidase, or sulfatase;

(iii) the inflammatory disease is rheumatoid arthritis, psoriatic arthritis, asthma, chronic obstructive pulmonary disorder, lupus, hepatitis, renal disease, sickle cell disease, fibromyalgia, irritable bowel syndrome, or an ulcer and at least one of the digesting enzymes is a sialidase, α-sialidase, hexosaminidase, galactosidase, fucosidase, or sulfatase; or

(iv) the disease is Alzheimer's disease or Parkinson's disease and at least one of the digesting glycan enzymes is a sialidase, a hexosaminidase, a galactosidase, a fucosidase, or a sulfatase.

12. A method monitoring the treatment of a disorder associated with the abnormal degradation, biosynthesis and/or accumulation of glycans, the method comprising:

(a) following administration of an agent for the treatment of the disorder to an individual in need thereof, using an analytical instrument to measure the amount of a population of a biomarker, wherein the biomarker was generated by treating a population of glycans, in or isolated from a biological sample from the individual to provide a transformed biological sample, with at least one digesting glycan enzyme(s), wherein the biomarker comprises one or more non-reducing end glycan residual compounds present in the transformed biological sample, and wherein prior to enzyme treatment, the biomarker is not present in abundance in the biological samples from individuals with the disorder relative to individuals without the disorder, and

(b) determining whether or not the amount of biomarker has decreased or has increased at a slower rate compared to the amount of the biomarker or compared to the rate of increase, respectively, prior to administration of the agent for the treatment of the disorder; and

wherein the disorder is a lysosomal storage disease, cancer, an inflammatory disease, a liver disease, a bone disease, an infectious disease, a central nervous system disease, or a cardiovascular disease; and

wherein when the disorder is an MPS disorder or osteoarthritis, then the digesting glycan enzyme is not a lyase.

13. The method of claim 12, wherein at least one of the digesting glycan enzymes is a sialidase, hexosaminidase, fucosidase, N-acetyl-transferase, glycosidase, sulfatase, phosphorylase, deacetylase, or a combination thereof.

14. The method of claim 12, wherein the glycan residual compound is a monosaccharide, sulfate, phosphate, acetate, or a combination thereof.

15. The method of claim 12, wherein the population of glycans is treated with a plurality of normally functioning glycan degradation enzymes concurrently, sequentially, or a combination thereof.

16. The method of claim 12, wherein prior to measuring the amount of the biomarker, the biomarker is labeled with a detectable label where the detectable label is a mass label, a radioisotope label, a fluorescent label, a chromophore label, or affinity label.

17. The method of claim 12, wherein the disorder associated with an abnormal glycan accumulation is MPS I, MPS II, MPS IIIA, MPS IIIB, MPS IIIC, MPS HID, MPS IVA, MPS IVB, MPS VI, or MPS VII.

18. The method of claim 17, wherein the disease, condition or disorder is:

(i) MPS I and at least one of the digesting glycan enzymes is an iduronidase;

(ii) MPS II and at least one of the digesting glycan enzymes is a 2-sulfatase;

(iii) MPS IIIA and at least one of the digesting glycan enzymes is an N-sulfatase;

(iv) MPS IIIB and at least one of the digesting glycan enzymes is a hexosaminidase or a deacetylase;

(v) MPS IIIC and at least one of the digesting glycan enzymes is hexosaminidase or an N-acetyl-transferase;

(vi) MPS IIID and at least one of the digesting glycan enzymes is 6-O-sulfatase;

(vii) MPS IVA and at least one of the digesting glycan enzymes is a 6-O-sulfatase, galactosidase, N-acetyl-galactosidase, or hexosaminidase;

(viii) MPS IVB and at least one of the digesting glycan enzymes is a galactosidase;

(ix) MPS VI and at least one of the digesting glycan enzymes is 4-O-sulfatase; or

(x) MPS VII and at least one of the digesting glycan enzymes is β-glucuronidase.

19. The method of claim 12, wherein the disease, condition or disorder is alpha mannodidosis, aspartylglucoaminuria, Fabry's disease, fucosidosis, galatosialidosis, Gaucher disease, GM1 gangliosidosis, GM2 activator deficiency, sialidosis, Krabbe disease, metachromatic leukodystrophy, mucolipidosis II, mucolipidosis III, mucolipodosis IV, multiple sulfatase deficiency, Pompe disease, Sandhoff disease, Tay-Sachs disease, AB variant, Schindler disease, alpha mannosidosis, beta mannosidosis, or globoid cell leukodystrophy.

20. The method of claim 19 wherein the disease, condition or disorder is:

(i) alpha mannodidosis and at least one of the digesting glycan enzymes is a mannosidase;

(ii) aspartylglucoaminuria and at least one of the digesting glycan enzymes is hexosaminidase;

(iii) Fabry's disease and at least one of the digesting glycan enzymes is a galactosidase;

(iv) fucosidosis and at least one of the digesting glycan enzymes is a fucosidase;

(v) galatosialidosis and at least one of the digesting glycan enzymes is a galactosidase and/or a sialidase;

(vi) Gaucher disease and at least one of the digesting glycan enzymes is a glucosidase;

(vii) GM 1 gangliosidosis and at least one of the digesting glycan enzymes is β-galactosidase;

(viii) GM 2 activator deficiency and at least one of the digesting glycan enzymes is hexosaminidase;

(ix) sialidosis and at least one of the digesting glycan enzymes is a sialidase;

(x) Krabbe disease and at least one of the digesting glycan enzymes is a galactosidase;

(xi) metachromatic leukodystrophy and at least one of the digesting glycan enzymes is 3-O-sulfatase;

(xii) mucolipidosis II and at least one of the digesting glycan enzymes is any listed enzyme in Table 1;

(xiii) mucolipidosis III and at least one of the digesting glycan enzymes is any listed enzyme in Table 1;

(xiv) mucolipidosis IV and at least one of the digesting glycan enzymes is any listed enzyme in Table 1;

(xv) multiple sulfatase deficiency and at least one of the digesting glycan enzymes is a sulfatase or glycosidase;

(xvi) Pompe disease and at least one of the digesting glycan enzymes is glucosidase;

(xvii) Sandhoff disease and at least one of the digesting glycan enzymes is hexosaminidase;

(xviii) Tay-Sachs disease and at least one of the digesting glycan enzymes is hexosaminidase;

(xix) AB variant and at least one of the digesting glycan enzymes is hexosaminidase;

(xx) Schindler disease and at least one of the digesting glycan enzymes is hexosaminidase;

(xxi) alpha mannosidosis and at least one of the digesting glycan enzymes is mannosidase;

(xxii) beta mannosidosis and at least one of the digesting glycan enzymes is mannosidase; or

(xxiii) globoid cell leukodystrophy and at least one of the digesting glycan enzymes is galactosidase.

21. The method of claim 12, wherein

(i) the infectious disease is a bacterial or fungal infection and at least one of the digesting enzymes is a mannosidase, fucosidase, glucosidase, galactosidase, hexosaminidase, arabinosidase, xylosidase, ribosidase, lyxosidase, talosidase, idosidase, gulosidase, altrosidase, or allosidase;

(ii) the infectious disease is a viral infection and at least one of the digesting enzymes is a sialidase, α-sialidase, hexosaminidase, galactosidase, fucosidase, or sulfatase; where the disease is coronary artery disease and at least one of the digesting enzymes is a sialidase, α-sialidase, hexosaminidase, galactosidase, fucosidase, or sulfatase;

(iii) the inflammatory disease is rheumatoid arthritis, psoriatic arthritis, asthma, chronic obstructive pulmonary disorder, lupus, hepatitis, renal disease, sickle cell disease, fibromyalgia, irritable bowel syndrome, or an ulcer and at least one of the digesting enzymes is a sialidase, α-sialidase, hexosaminidase, galactosidase, fucosidase, or sulfatase; or

(iv) the disease is Alzheimer's disease or Parkinson's disease and at least one of the digesting glycan enzymes is a sialidase, a hexosaminidase, a galactosidase, a fucosidase, or a sulfatase.

* * * * *